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Technical Note N-1058

AIRFIELD PAVEMENT EVALUATION, ROYAL THAI NAVY STATION, BAN U-TAPAO AIRFIELD, THAILAND

By

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December 1969

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ABSTRACT

The reevaluation of the pavement at the Royal Thai Navy Station, Ban U-Tapao Airfield, Thailand is presented with the allowable gross load capacities of all airfield pavements for various aircraft gear configurations. Included are a narrative-type pavement condition survey with a defect summary, supplementary photographs, and estimates of remaining runway pavement life.

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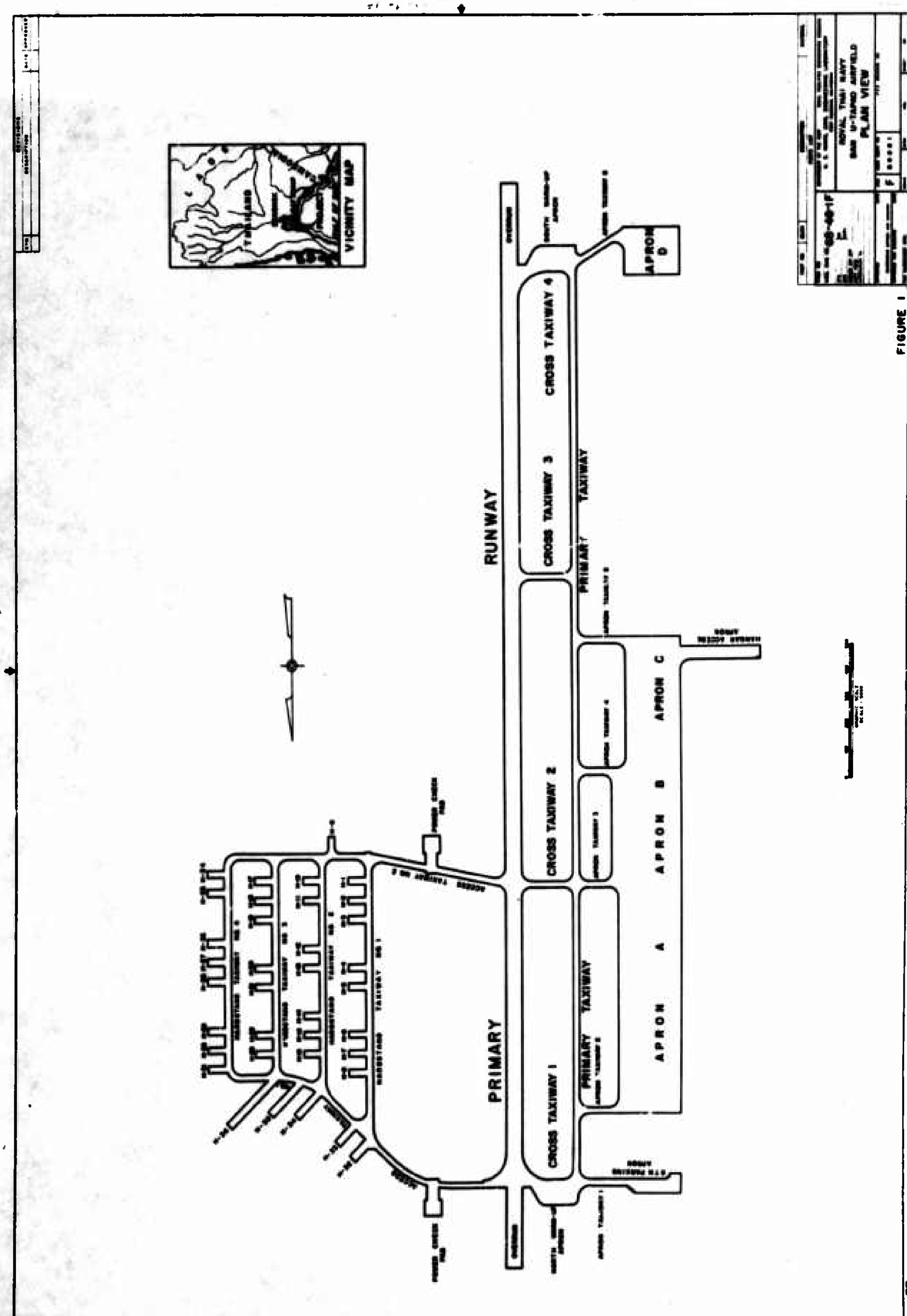
RUNWAY
PRIMARY
CROSS TAXIWAY 1
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PRIMARY TAXIWAY
APRON A
APRON B
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VICINITY MAP
THAILAND
ROYAL THAI NAVY
PLAN VIEW

FIGURE 1

BACKGROUND

Ban U-Tapao Airfield is located at longitude 12°-40'-40" North, latitude 100°-00'33" West, approximately 130 kilometers by air southeast of Bangkok, Thailand. The altitude of the field is 12.84 meters above mean sea level at the centerline of the runway. A plan view of the station can be found in Figure 1.

During the months of June and July, 1968, the Naval Civil Engineering Laboratory (NCEL) conducted a comprehensive airfield pavement evaluation of Ban U-Tapao Airfield, the results of which were published in NCEL Technical Note N-986, entitled "Airfield Pavement Evaluation, Royal Thai Navy Station, Ban U-Tapao, Thailand," dated August, 1968 (Reference 1).

In July 1969, NCEL airfield evaluators were again called to Ban U-Tapao Airfield, at which time a comprehensive reevaluation of the airfield was performed. The 1969 reevaluation is the subject of this report.

GEOLOGY

The airfield is situated on the alluvial plains of the southeast coastal region of Thailand which is bounded on the west and south by the Gulf of Thailand, on the east by the flat-topped hills of the Banthat Range and on the north by the hills and mountains along the southern edge of the Prachin River valley.

The flat coastal flood plains that separate the hills from the Gulf of Thailand are criss-crossed by many gullies and ditches in dendritic drainage patterns. There are no large rivers or drainage basins along the southeast coast, but many small streams carry water from the uplands to the sea. The two major outlets to the sea in the Sattahip-U-Tapao area are the Klong Bang Phai which flows through the project site, and the Klong Huai Pong. The coast line is a sunken one, and the numerous offshore islands are peaks of drowned landscape.

In the airfield area are found quaternary deposits of unconsolidated silt, sand and gravel, beach and estuarine clay, and residual layers of laterite capping shale, sandstone and sandy shale containing some limestone beds.

Quarries near the base have been producing a widely-used fill material (called "jinglestone" locally) from interlayered deposits of sandstone, shale, sandy shale, and slate. This material was exclusively used for roads during construction of the airfield and showed good stability, even during wet weather. A dense gray limestone is being quarried and crushed farther north at the Navy quarry for use as asphaltic and portland cement concrete aggregate. (See Reference 2).

CLIMATIC DATA

Temperature, evaporation, and rainfall data for the Ban U-Tapao area can be found in Figures 2 and 3.

FACILITY DESIGN AND CONSTRUCTION HISTORY

All of the pavements were constructed in the years 1966 to 1968 and were designed in accordance with procedures set forth in AFM 88-6, Chapter 3, "Airfield Pavement Design, Engineering and Design, Rigid Pavement." The runway, parallel and connecting taxiways, access and hardstand taxiways, north warm-up apron, and all hardstands were designed for heavy load to support a landing gear load of 265,000 pounds, carried on twin-twin wheels spaced 37 x 62 x 37 inches, bicycle arrangement, each wheel having a contact area of 267 square inches. All parking aprons and the south warm-up apron were designed for medium load to support a landing gear load of 100,000 pounds carried on twin wheels spaced 37-1/2 inches, tricycle arrangement, each wheel having a contact area of 267 square inches. A general summary of individual pavement facilities showing pavement type, dimensions, and approximate date of construction is shown in Table 1. It should be noted that at the recommendation of the base operations and engineering officers, and due to the important role presently played by the station, pavement facilities were not divided into primary and secondary groupings, but were all considered of equal importance. A plan view of the station with detailed dimensions is presented in Figure 4. Typical sections for most pavement facilities are shown in Figures 5 through 9. Physical characteristics of the pavement and foundation materials are given in Table 2.

CONDITION SURVEY

All methods and procedures followed during the pavement condition survey at Ban U-Tapao Airfield were dictated by Corps of Engineers Manual EM-1110-45-753 App. III. Every pavement section at the station was visually inspected and each visible defect tallied. Defects were grouped into major and minor defects according to the following definitions:

Major Defect - A major defect is defined as a crack or break in a concrete slab that will impair the load carrying capacity of the pavement. The defect usually extends throughout the depth of the slab; thus the individual concrete slab is subdivided by the crack into two or more parts.

Minor Defect - A minor defect is defined as a crack or break in the slab that is generally confined to the surface of the concrete and does not extend throughout the depth of the slab. These defects often cause undesirable surface conditions but do not impair the structural capacity of the concrete to carry load. Minor defects may or may not develop into major defects through continued use of the pavement, but can generally be repaired by normal maintenance operations.

Predominant major defects found at Ban U-Tapao Airfield were longitudinal, transverse, and corner break cracks. Minor defects noted included joint spalls, corner spalls, embedded wood, and popouts.

During the present (1969) evaluation, most pavement facilities were found to contain more major and/or minor defects than were found during the 1968 evaluation (Reference 1). Only a few facilities, however, contained enough additional defects to warrant a reduction in their condition rating. The runway, for example, was reduced one rating step (from "excellent" in 1968 to "very good" in 1969) due to a 7.7 percent increase in cracked center lane slabs during the past year. The western portion of Access Taxiway 1, rated "excellent" in 1968 when no visible defects were present, experienced severe cracking and pumping in the center (or travelled) lane during the past year and was reduced to the lowest condition rating of "failed." Other pavement facilities which were given lower ratings during the 1969 evaluation than during the 1968 evaluation were Hardstand Taxiway 1; Cross Taxiway 4; Apron Taxiway 2 and Hardstand No. 5. All these rating decreases were occasioned by an increase in the number of slabs in each containing major pavement defects.

The primary taxiway contained very few more cracked slabs than in 1968 and thus retained its "excellent" rating. It should be noted that the primary taxiway contained many centerline-type longitudinal cracks which could have warranted a lower rating if judged solely on a defect count basis. However, in the judgement of the evaluators, the load carrying capacity has not been reduced, thus the pavement was rated "excellent." A more detailed explanation of this particular rating action is presented in the "Comments" section of this report.

A detailed, narrative-type condition survey of each individual pavement facility, along with supplementary photographic coverage of typical defects can be found in Appendix A.

ALLOWABLE GROSS AIRCRAFT LOADS

Ban U-Tapao Airfield was designed for the capacity operational category, and contains pavement sections designed for Types A, B and C traffic areas.

Allowable gross aircraft loadings for each pavement facility have been developed, based on the above criteria in combination with the following design parameters:

Concrete Flexural Strength

Desired (design) concrete flexural strength for all pavements at the airfield was 700 psi (90-day strength) using a 5.75 to 6 bag concrete mix. Field curing of concrete was accomplished using a membrane curing compound. Representative concrete beams were formed, vibrated, cured in a water bath and subsequently broken to obtain the concrete flexural strength for each pavement facility. Thousands of these beams were tested. Average 90-day flexural strength for each pavement facility ranged from a low of 705 psi for Hardstand Taxiway 1 to a high of 945 psi (average of 316 beams) for Runway 18-36. These values were considered exceptionally high.

To check these figures, a limited number of cores were taken from selected pavements at the time of the 1968 evaluation. These cores were tested in tensile splitting. Such test results were related to flexural strength by the relationship:

Flexural Strength = Tensile Splitting + 200 psi

Results of tensile splitting tests yielded uniformly lower flexural strengths ranging from 580 to 700 psi for concrete areas where beam flexural strengths ranged from 705 to 890 psi. Flexural strengths determined from tensile splitting tests of cores were roughly 120 psi lower than equivalent beam flexure tests.

It was felt that the reduced flexural strengths determined from tensile splitting tests were more valid based on the fact that the cores represented actual in-place concrete rather than hand-molded, separately-cured beam specimens. Thus, the flexural strengths used in the 1968 evaluation were obtained by subtracting 120 psi from the average of beam flexural strengths for each individual pavement facility. During the present (1969) evaluation no additional data was found that would affect the previously-determined flexural values. Therefore, the above criteria (i.e., the actual beam test flexural strength reduced by 120 psi) was again used for selection of flexural strength values listed in Table 2 and in calculation of allowable gross aircraft loads shown in Table 3.

<u>Modulus of Subgrade Reaction (k)</u>

Most of the pavement at the station is located on jinglestone fill, usually more than one meter in depth. During construction, some density tests were made on the jinglestone, but compaction control for the method-type rolling specification used was based on plate bearing tests on the fill material. Hundreds of plate bearing tests were conducted. The average of these tests was well above the maximum "k" of 500 pci allowed in design procedures. In the 1968 evaluation, however, partial reduction of subgrade support was considered a factor in some instances of pavement distress. This could be explained by the fact that stresses from heavy bomber loadings may penetrate to deeper (and weaker) soil strata than did the stresses from plate bearing tests used to obtain the "k" values. At that time, a conservative "k" value of 400 pci was adopted for evaluation of all pavement facilities. One deviation from this policy occurred in the west end of Access Taxiway 2, where the evaluation "k" value was arbitrarily reduced to 300 pci due to a wet subgrade and obvious pavement failures.

General pavement performance since the 1968 evaluation has supported the choice of a 400 pci "k" value. An exception was the accelerated cracking experienced in the west end of Access Taxiway 1; but this can, at best, be only partially attributed to a weakening of subgrade support. The lower concrete flexural strength found in Access Taxiway 1 and the traffic intensity must be considered equal contributors to that particular failure. Thus, the 1968 evaluation value of 400 pci subgrade support was again adopted for most pavement facilities.

Pavement Thickness

A list of pavement thicknesses for each pavement facility can be found in Table 2. Figure 4 also provides pavement thickness data.

Traffic Areas

For most pavement areas, allowable aircraft loads have been computed using the traffic area criteria used in the design. Several facilities, however, while designed for lesser traffic, are actually receiving channelized (Type A) traffic. For these facilities, allowable aircraft loads are provided for both traffic criteria. Included in these areas are Access Taxiways 1 and 2, Hardstand Taxiways 1 and 2, and that portion of Runway 18-36 used as a through taxiway between Access Taxiway 2 and Cross Taxiway 2.

A tabulation of allowable aircraft loads is presented in Table 3. Table 4 relates the various gear configurations with present-day aircraft.

COMMENTS

In the early 1950's, the Corps of Engineers obtained data which indicated that rigid pavements constructed on high strength foundations ("k" greater than 300 pci) continued to satisfactorily carry the design traffic for long periods after the slabs had cracked. (See Reference 3). Based on these observations, the decision was reached that more than initial cracking could be tolerated in pavements constructed on high strength foundations without causing undue aircraft or maintenance problems. Following this, a reduction was made in the design thickness of rigid pavements constructed over high "k" subgrades. Thus, some cracking is "built-into" and must be expected in pavements constructed to these criteria. Similarly, it should be assumed that, since most pavements at Ban U-Tapao contained relatively few cracks, these pavements have been and will continue to be structurally sound.

Another problem at Ban U-Tapao which is peculiar to the station but related to underlying principles of Air Force pavement design criteria is that of accelerated aircraft operations. As pointed out in the 1968 evaluation report, the capacity operational category for which the field was designed equates to an expected life of about 10,000 "coverages" or roughly 20,000 loaded B-52 launches for Type A traffic areas (Reference 4). Pavements at Ban U-Tapao are receiving traffic of several times the normal rate and cannot, on this basis, be expected to last as long as normally-used pavements. That is, unless such parameters as pavement thickness, flexural strength, or subgrade support exceed the design values. It should be noted here that only loaded B-52 operations are effective in reducing pavement life. Unloaded B-52 and other lighter aircraft operations do not have any appreciable effect on the pavement. Since the runway at Ban U-Tapao is the most critical pavement facility to the mission of the station, a more detailed study of its future life expectancy has been made and is presented in Appendix B.

Ban U-Tapao Airfield cannot, in its entirety, be uniformly evaluated with regard to the above concepts. A few important pavement facilities are briefly discussed, however, in the following paragraphs:

Runway 18-36

Although the single runway receives all operations of all aircraft at the station, loaded or unloaded, it has an unusually high concrete flexural strength (825 psi, far above the design requirement of 700 psi) and a generally strong subgrade support. Even after almost three years of operation of B-52 aircraft, a large majority of the critical center lane slabs have not yet been cracked. Not one of those which have cracked has yet reached a "shattered slab" condition (6 or more pieces). No evidence of slab movement; faulting of cracks, joints, or corner breaks; or pumping action was found. On this basis, the runway pavement is performing in an acceptable manner and has an extended useful life even at the present accelerated rate of traffic. (See Appendix B).

It was noted that about half the pavement defects found on the runway had not received maintenance. It is thus recommended, in light of the accelerated traffic rate, that all cracks be routed and sealed, and all spalls and similar pavement breaks be patched to prevent further deterioration of these defects into FOD problems.

During the evaluation, serious consideration was given to pilot reports of rough aircraft response to the surface profile of the runway. Although other engineering efforts to identify locations and causes of pavement roughness were already underway, NCEL evaluators made concerted efforts to locate possible pavement irregularities with a ten-foot straightedge. Little was found with the straightedge, however, leading to the conclusion that the roughness-causing elements in the pavement surface were of relatively long wavelength. At the conclusion of the NCEL evaluation, continuing Air Force and OICC-Thailand efforts were underway to determine remedial measures for this potentially serious problem.

Parallel Taxiway

On this taxiway the pavement is in excellent condition except for many longitudinal cracks occurring along the crown of the center lane. This type of distress has been observed on primary taxiways of other heavy design airfields and is not of serious concern. It can be avoided by sawing a longitudinal joint in the center lane as was done extensively at U-Tapao, even though the Air Force criterion does not call for such. These sawed or naturally-formed joints were not considered to have reduced the load-carrying capacity of the pavement, and were thus assigned to a minor category for this evaluation.

Only about 16 to 20 percent of all loaded B-52 aircraft operations make use of this taxiway. It thus receives what at other B-52 bases would be considered a "normal" rate of traffic. Also, very few new cracks were found during the present evaluation. This pavement facility can thus be assumed to have a life expectancy greater than that of the runway.

Maintenance on the taxiway has been performed to a larger extent than on the runway. About 95 percent of all cracks have been routed and sealed, and additional work was being done during the period of evaluation.

Access Taxiway 1

Although this facility showed no distress at the time of the 1968 evaluation, the evaluation report warned that the combination of Type B Traffic design (16-in. thickness), the traffic intensity, and a relatively low concrete strength would contribute to its early failure. This prediction was borne out by the relatively sudden failure of many center lane slabs (in the west portion) in early 1969. The eastern portion of the taxiway, located at the foot of a small hill, undoubtedly receives a greater degree of subgrade support and remains in excellent condition. It is interesting to note that, compared to the design life basis of 10,000 loaded B-52 "coverages" for Type A Traffic areas (Reference 4); this taxiway, designed to a lesser thickness (Type B Traffic area), failed at just over 9,000 loaded B-52 "coverages"--very close to the number at which it could be expected to fail if all construction specifications of concrete and soil strength were met.

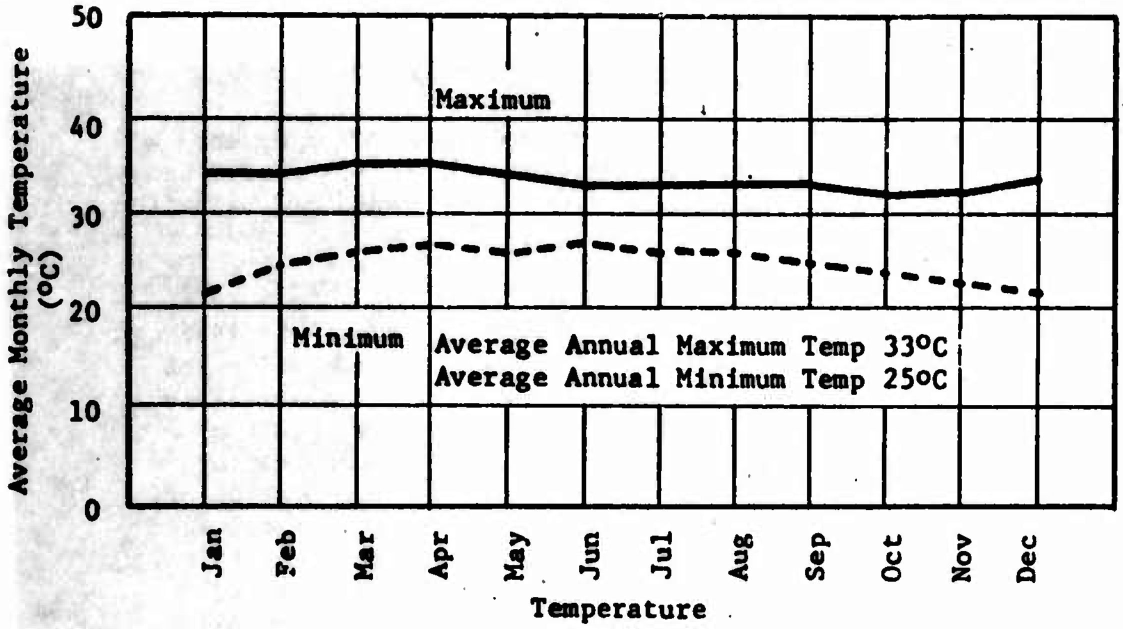
Access Taxiway 2

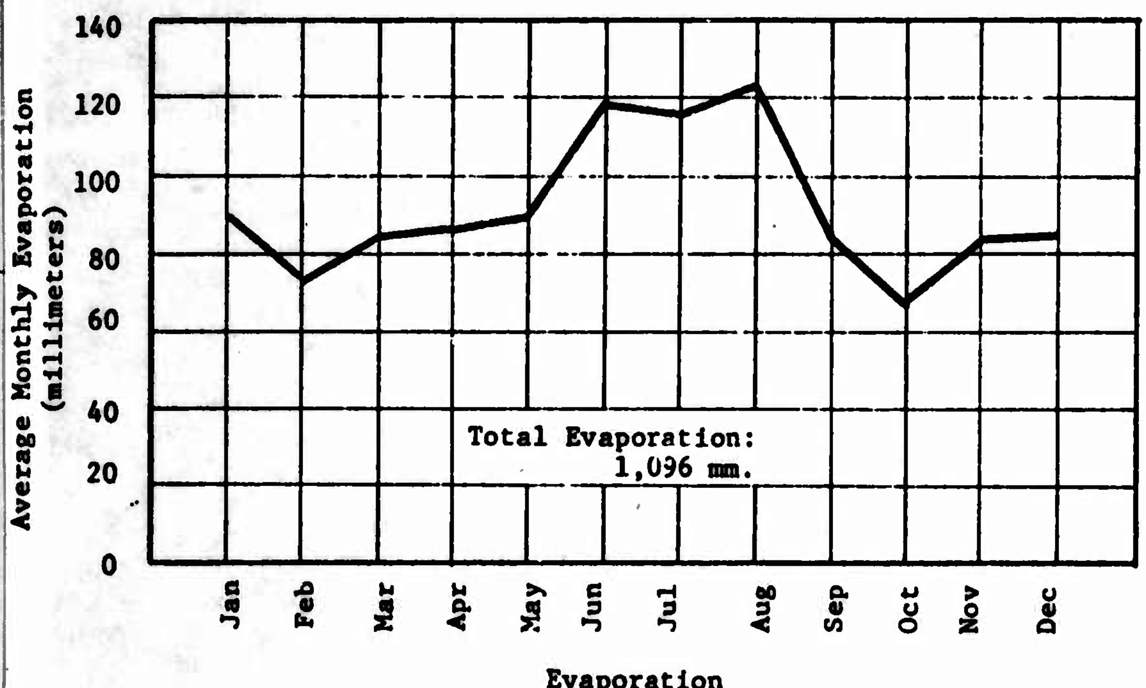
In 1968, the western half of this taxiway rated "poor," and contained many cracks, most of which could be identified as load cracks. In the period between the 1968 and present (1969) evaluation, this western portion of Access Taxiway 2 was rebuilt: much of the original jinglestone fill was removed and replaced with new, compacted jinglestone, and new concrete was placed (18-in. center lane, 16-in. outer lanes). For purposes of this evaluation the subgrade support value was estimated at 350 pci (compared to the 300 pci assumed in the 1968 evaluation) and the flexural strength of the new concrete was assumed to be 700 psi.

Hardstand Taxiway 1

Approximately the first 500 feet of this taxiway (adjacent to Access Taxiway 2) showed signs of distress soon after construction and was replaced. (See Figure 4). The replaced section exhibits very high concrete flexural strength and the underlying jinglestone fill is about one meter thicker than under other sections of this taxiway. No further distress is expected in this area.

The remainder of the taxiway, however, contains relatively poor concrete (lowest flexural strength on the station); less than average subgrade support, particularly on the South half; and receives Type A traffic on a pavement thickness designed for Type B traffic. Traffic intensity, however, is far lighter than on either of the access taxiways or other primary facilities. Thus, the prognosis for this pavement section is that it will probably occur more gradually than other pavement failures experienced to date on the station.

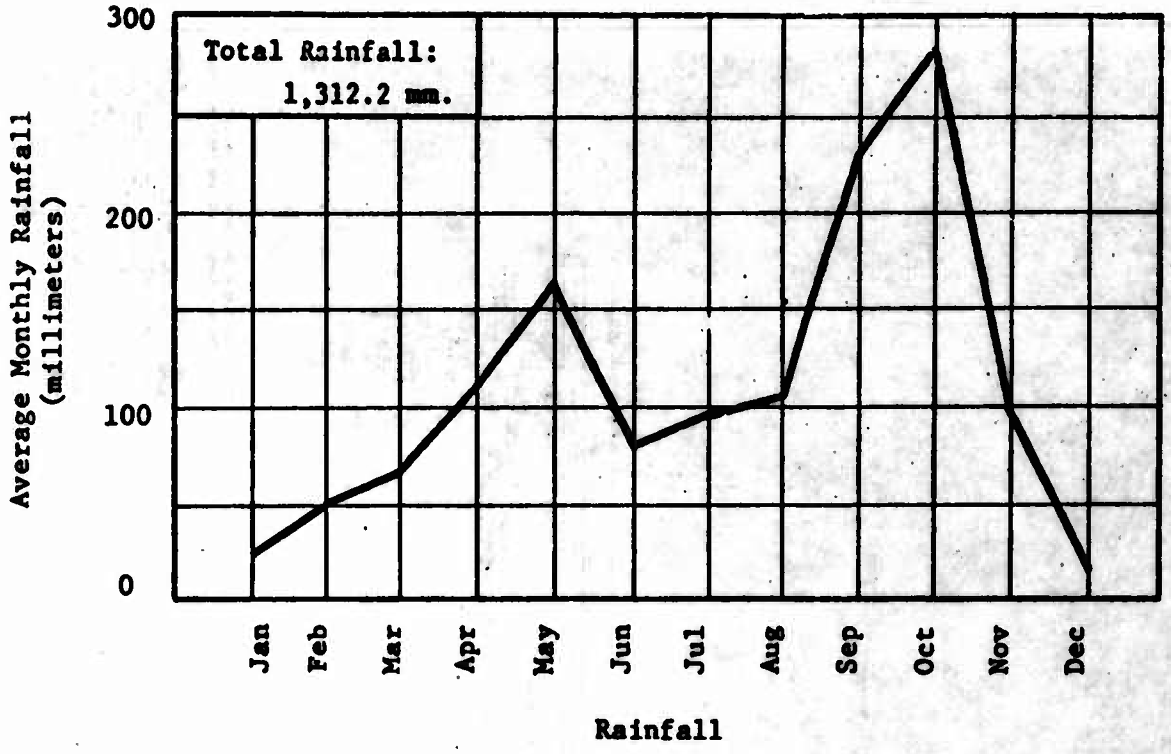


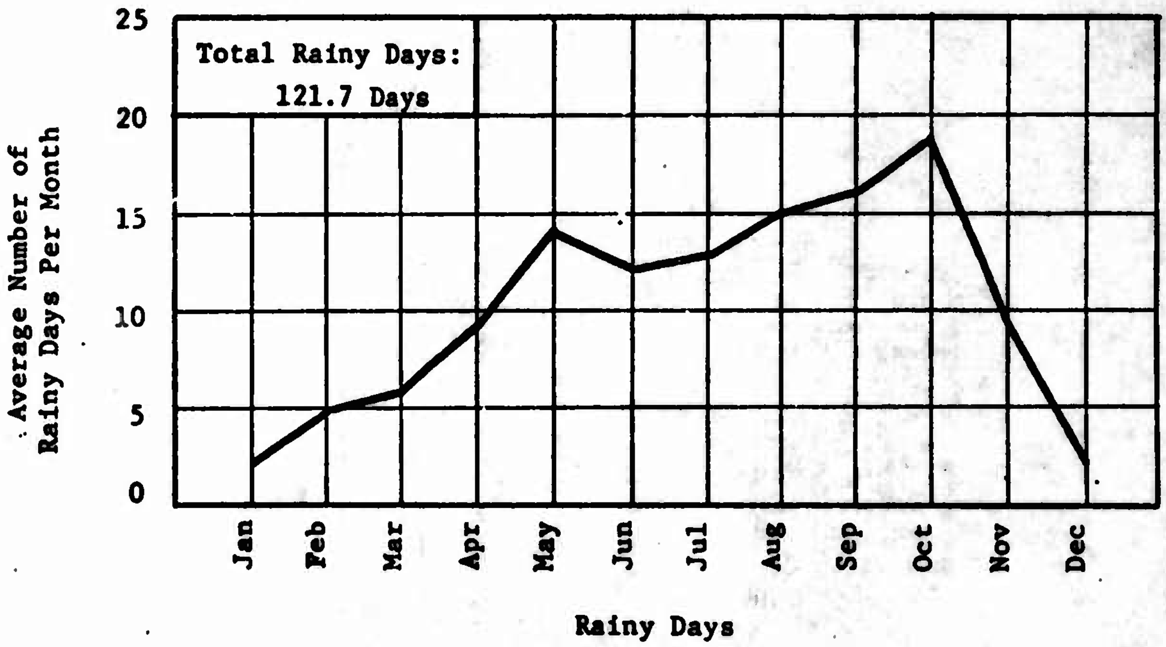


From: Royal Thai Naval Air Station--Ban U-Tapao Soils and Foundation Report, NBy 73038, Louis Berger-Von Storch and Burkavage

Source: Meteorological department, Bangkok.

Figure 2. Temperature and Evaporation Data for Ban U-Tapao Airfield.





From: Royal Thai Naval Air Station--Ban U-Tapao Soils and Foundation Report, NBy 73038, Louis Berger-Von Storch and Burkavage

Note: Data from 30-year record (1931-1960)

Source: Meteorological department, Bangkok.

Figure 3. Rainfall and Rainy Day Data for Ban U-Tapao Airfield

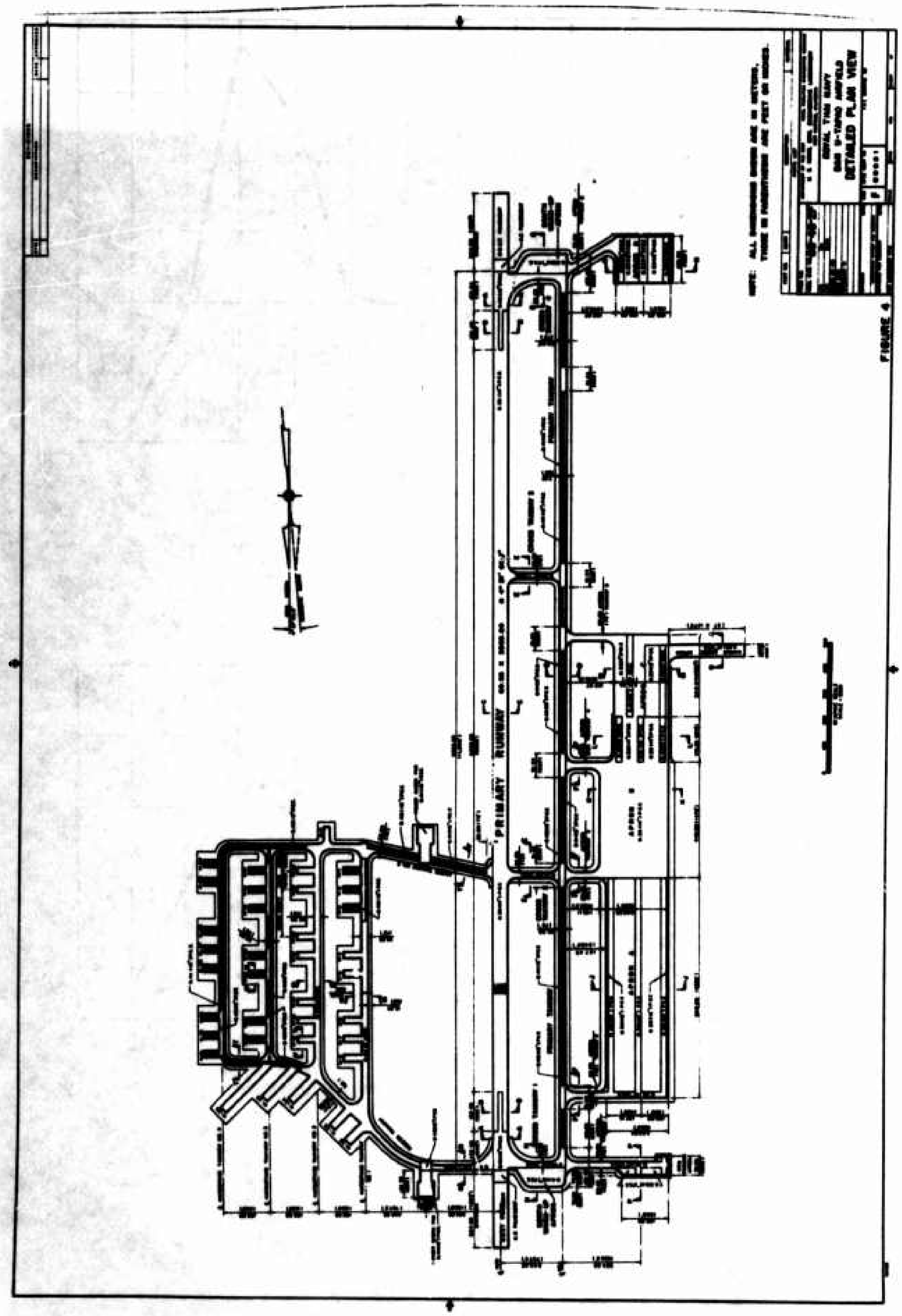
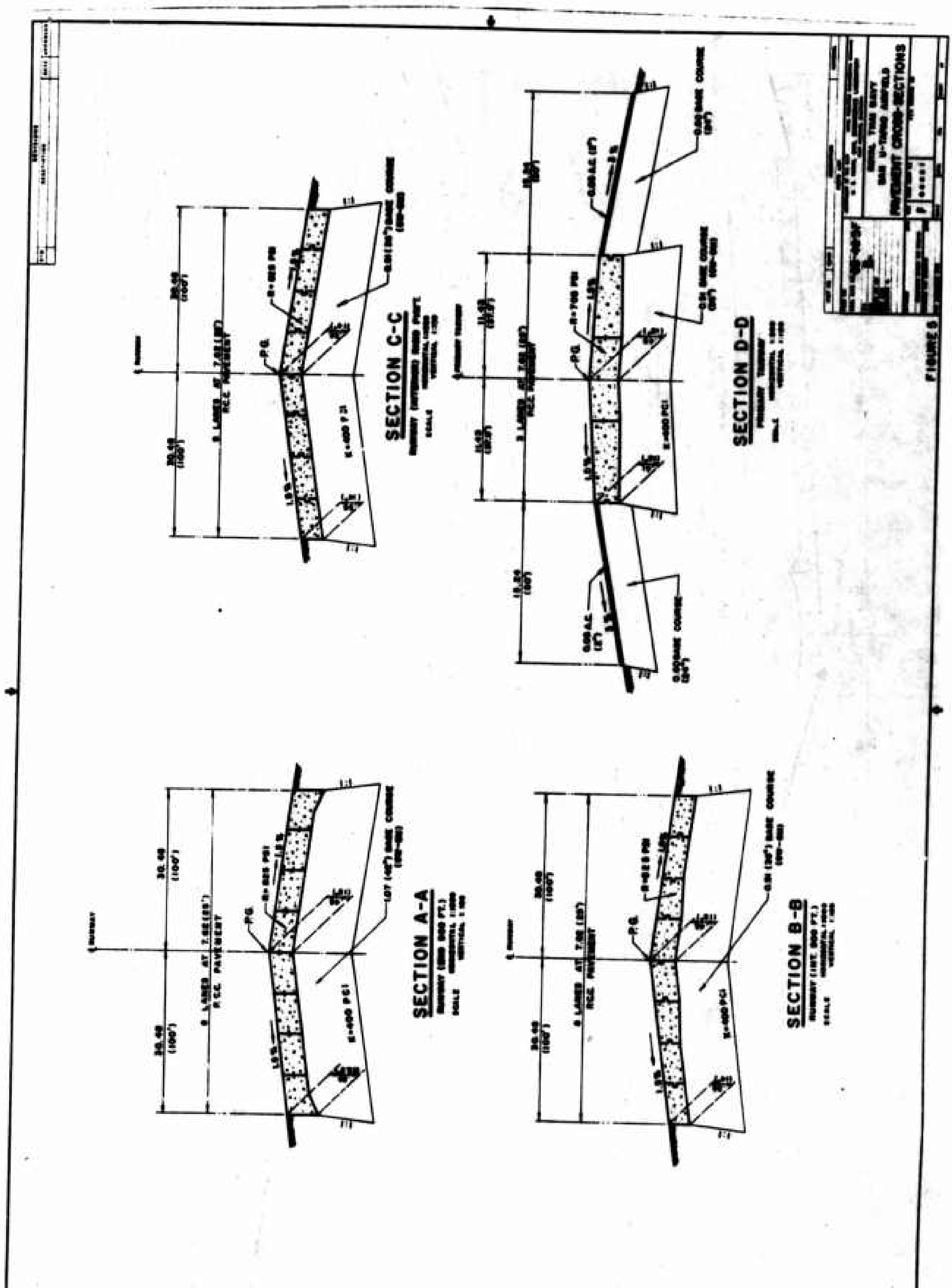


FIGURE 4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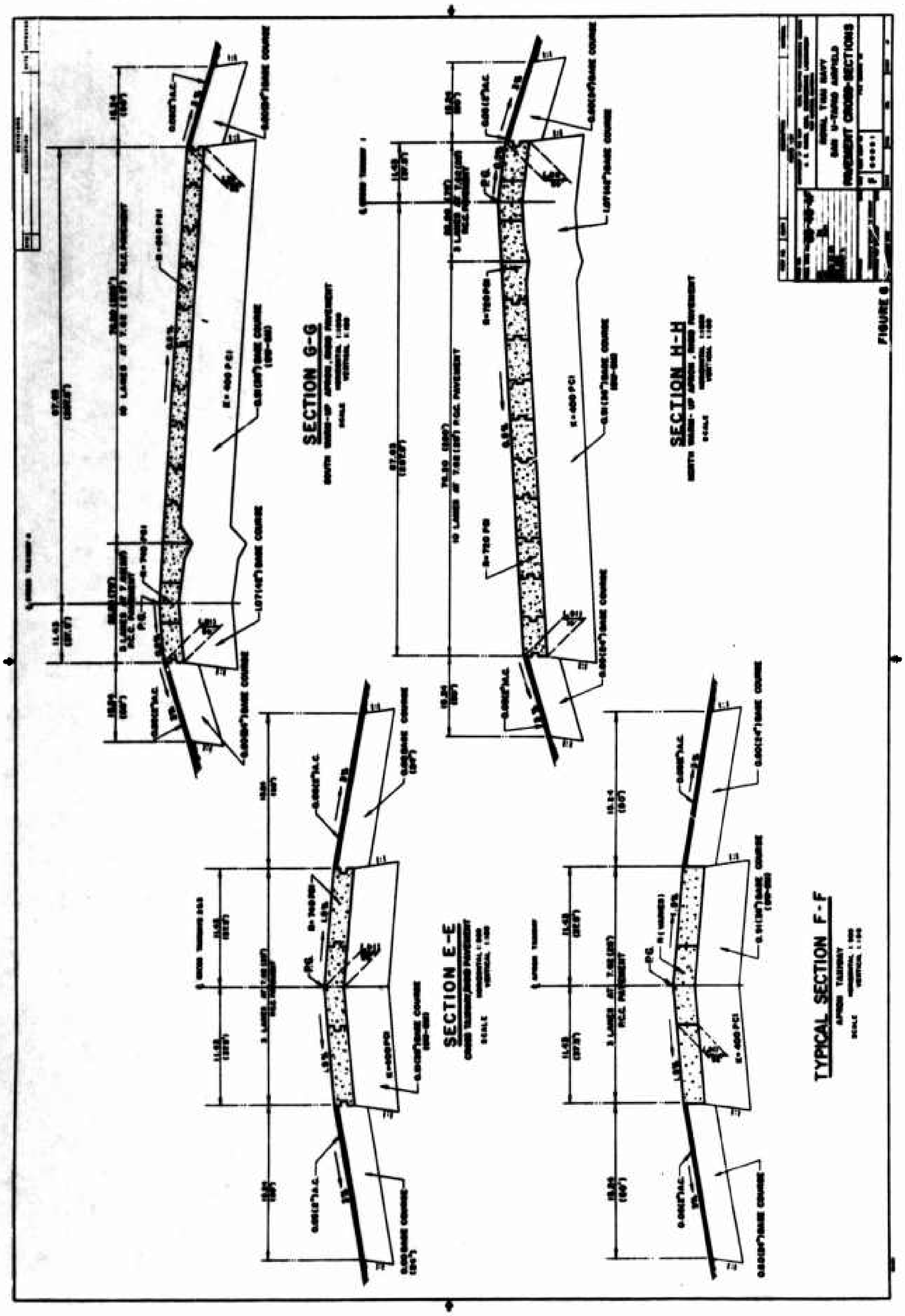
SECTION A-A
SECTION B-B
PAVEMENT CROSS-SECTIONS
FIGURE 5



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SECTION H-H
SECTION E-E
TYPICAL SECTION F-F
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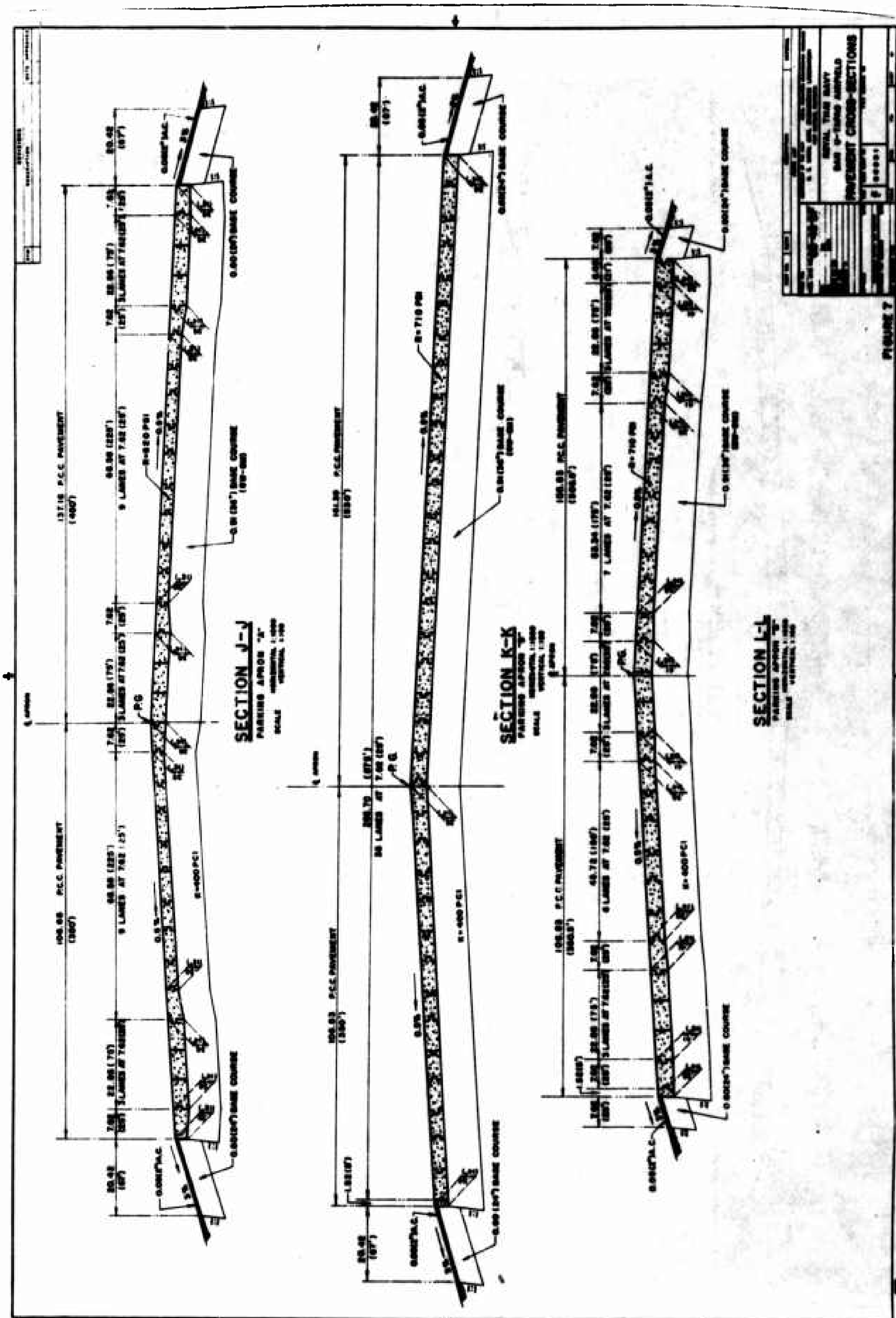
FIGURE 6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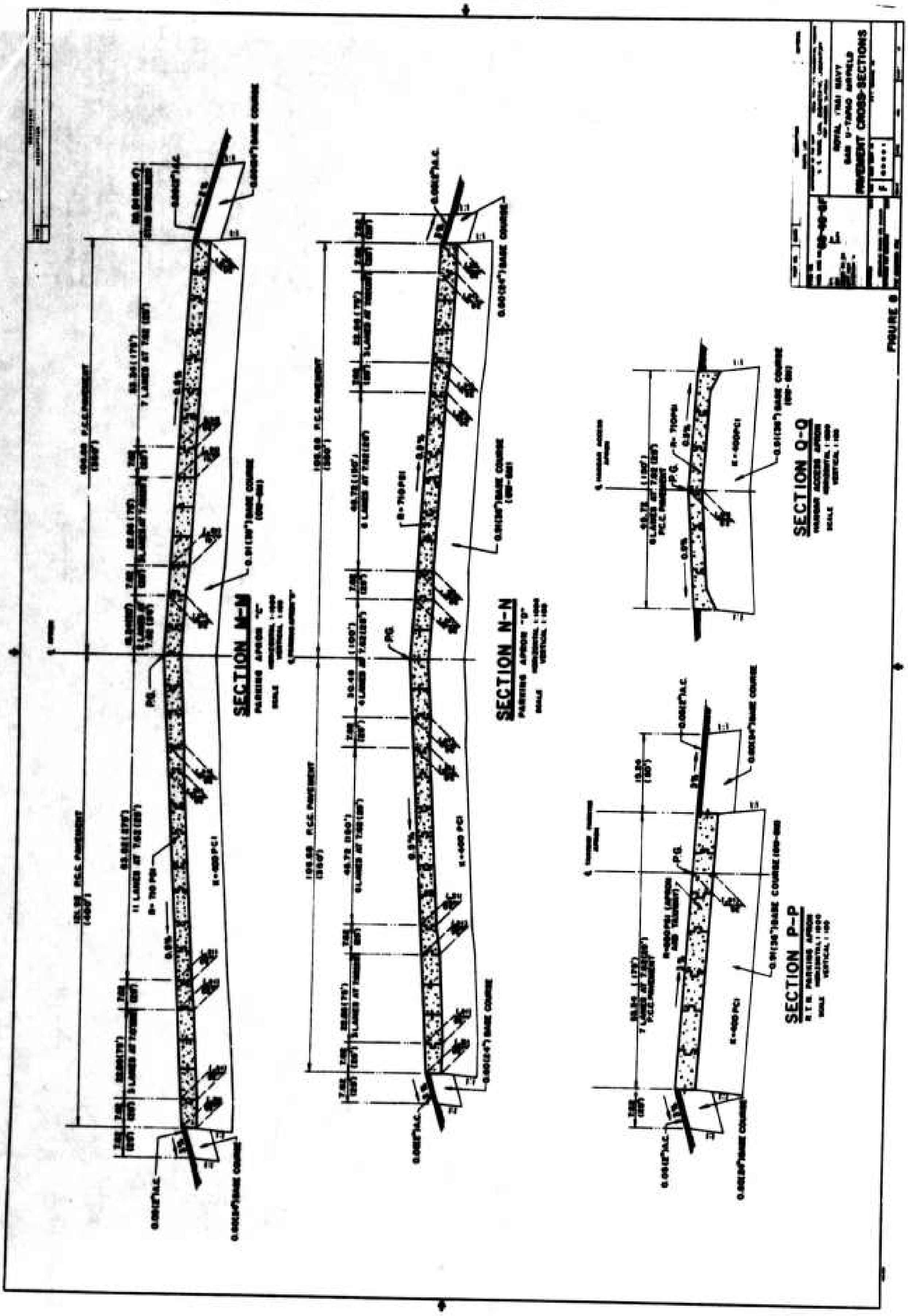
SECTION K-K
SECTION L-L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PARKING APRON "C"
SECTION N-N
PARKING APRON "D"
SECTION P-P
SECTION Q-Q
HANGAR ACCESS APRON
ROYAL THAI NAVY
PAVEMENT CROSS-SECTIONS
FIGURE 8

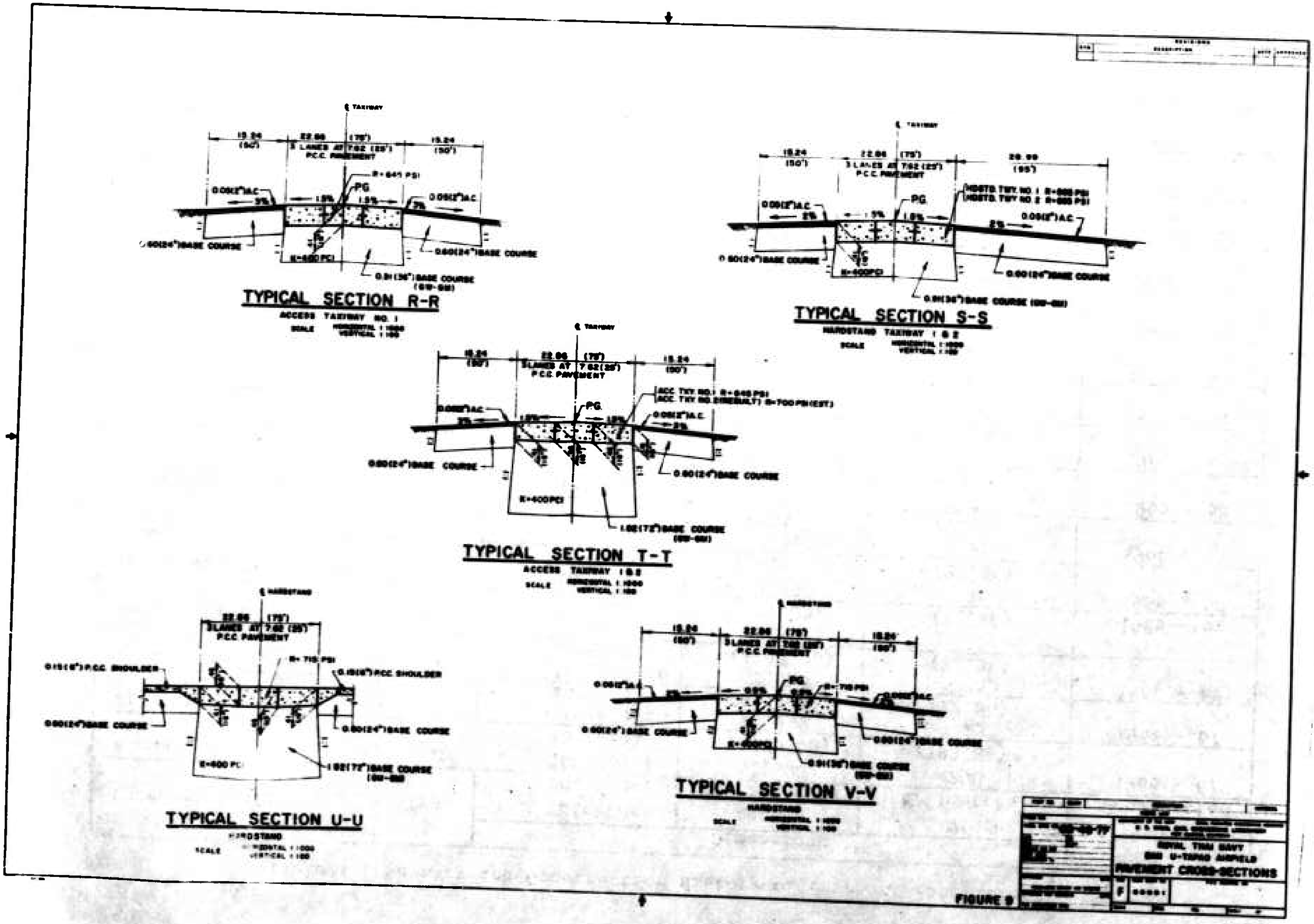

TYPICAL SECTION R-R
ACCESS TAXIWAY NO. 1
TYPICAL SECTION S-S
HARDSTAND TAXIWAY 1 & 2
TYPICAL SECTION T-T
ACCESS TAXIWAY 1 & 2
TYPICAL SECTION U-U
HARDSTAND
TYPICAL SECTION V-V
HARDSTAND
ROYAL THAI NAVY
U-TAPAO AIRFIELD
PAVEMENT CROSS-SECTIONS
FIGURE 9

Table 1. Summary and Construction History of Pavement Facilities

Pavement Facility	Type	Dimensions			Date Constructed
		Thickness in. (cm.)	Length ft. (meters)	Width ft. (meters)	
Runway 18-36	PCC	14"(36) to 18"(46)	11,500 (3200.40)	200 (182.88)	1966 - 67
Primary Taxiway	PCC	16"(41) to 18"(46)	10,950 (3337.50)	75 (22.86)	1966 - 67
Access Taxiway #1	PCC	16"(41) to 18"(46)	3,920 (1195.00)	75 (22.86)	1966 - 68
Access Taxiway #2	PCC	16"(41) to 18"(46)	2,700 (827.00)	75 (22.86)	* 1966 - 68
Hardstand Taxiway #1	PCC	16"(41) to 18"(46)	3,650 (1113.25)	75 (22.86)	1966 - 68
Hardstand Taxiway #2	PCC	16"(41)	2,665 (820)	75 (22.86)	1966 - 68
Hardstand Taxiway #3	PCC	16"(41) to 18"(46)	2,567 (790)	75 (22.86)	1966 - 68
Hardstand Taxiway #4	PCC	16"(41) to 18"(46)	650 (200)	75 (22.86)	1966 - 68
Cross Taxiway #1 & 4	PCC	18"(46)	650 (200)	75 (22.86)	1966 - 67
Cross Taxiway #2 & 3	PCC	14"(36)	650 (200)	75 (22.86)	1966 - 67
Apron Taxiway #1, 2, 3, 4 & 6	PCC	14"(36)	650 (200.0)	75 (22.86)	1966 - 67
Apron Taxiway #5	PCC	16"(41)	612.5 (186.54)	75 (22.86)	1966 - 67
Parking Apron A	PCC	12"(30) to 14"(36)	2,850 (868.68)	800 (243.84)	1966 - 67
Parking Apron B	PCC PCC	14"(36) 14"(36)	1475(449.58) 575(175.26)	880(268.22) 700(213.66)	1966 - 67 1966 - 67
Parking Apron C	PCC	12"(30), 14"(36) & 16"(41)	1,050 (320.04)	700 (213.66)	1966 - 68
Parking Apron D	PCC	14"(36)	625 (190.50)	700 (213.66)	1966 - 67

* West Half Rebuilt 1969

Table 1. (Cont'd) Summary and Construction History of Pavement Facilities

Pavement Facility	Type	Dimensions: Thickness in. (cm.)	Length ft. (meters)	Width ft. (meters)	Date Constructed
Royal Thai Navy Apron	PCC	12"(30) to 14"(36)	600 (182.88)	175 (53.54)	
Hanger Access Apron	PCC	12"(30)	975 (297.18)	150 (45.72)	1966 - 67
North Warm-up Apron	PCC	16"(41)	Area = 15,480 Sq. Yds. (12,943 Sq. M.)		1966 - 67
South Warm-up Apron	PCC	12"(30)	Area = 15,719 Sq. Yds. (13,143 Sq. M.)		1966 - 67
Hardstands	PCC	16"(41) to 18"(46)	225 (68.58)	75 (22.86)	1967 - 68
North & South Power Check Pads	PCC	16"(41)	475 (144.9)	225 (68.58)	1967 - 68

Table 2. Summary of Physical Property Data

Facility No. and Identification	Pavement			Base			Subgrade	General Condition of Area
	Thickness in. (CM.)	Description	Flex. Str. psi	Thickness in. (CM.)	Description	K pci	Classification	
Runway 18-36 1st 500 ft. ends	18 (46)	P.C.C.	825	42 (107)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Very Good
Runway 18-36 2nd 500 ft. ends	18 (46) 14 (36)	P.C.C. (Center 50') P.C.C. (Outer Lanes)	825	36 (91)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Very Good
Runway 18-36 Interior	14 (36)	P.C.C.	825	36 (91)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Very Good
Primary Taxiway	18 (46) 16 (41)	P.C.C. (Center 25') P.C.C. (Center Lanes)	705	36 (91)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Excellent
Access Taxiway 1 (West)	16 (41)	P.C.C. (West 825')	645	36 (91)	Jinglestone* GW-GM		Brown Silty Sand (SM)	Excellent
Access Taxiway 1 (East)	18 (46) 16 (41)	P.C.C. (Center 25') P.C.C. (Rest of Taxiway)	645	36 (91)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Excellent
Access Taxiway 2	18 (46) 16 (41)	P.C.C. (Center 25' East 275' West 1600') P.C.C. (Rest of Taxiway)	700 est.	36 (91)	Jinglestone* GW-GM		Brown Silty Sand (SM)	Excellent
Hardstand Taxiway 1	18 (46) 16 (41)	P.C.C. South 750' (See Fig. 4) P.C.C. (Rest of Taxiway)	725 580	72 (180) 36 (91)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Very Good

* Jinglestone was quarried from interlayered deposits of sandstone, shale, sandy shale and slate.

Table 2. Summary of Physical Property Data (Cont'd)

Facility No. and Identification	Pavement			Base			Subgrade	General Condition of Area
	Thickness in. (CM.)	Description	Flex. Str. psi	Thickness in. (CM.)	Description	K pci	Classification	
Hardstand Taxiway 2	16 (41)	P.C.C.	695	36 (91)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Excellent
Hardstand Taxiway 3	18 (46) 16 (41)	P.C.C. (Center 25') P.C.C. (Outer Lanes)	700	72 (180)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Excellent
Hardstand Taxiway 4	18 (46) 16 (41)	P.C.C. (Center 25') P.C.C. (Outer Lanes)	770	72 (180)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Excellent
Cross Taxiway 1	18 (46)	P.C.C.	770	42 (107)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Excellent
Cross Taxiway 2	14 (36)	P.C.C.	740	36 (91)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Excellent
Cross Taxiway 3	14 (36)	P.C.C.	740	36 (91)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Excellent
Cross Taxiway 4	18 (46)	P.C.C.	740	42 (107)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Good
Apron Taxiway 1	14 (36)	P.C.C.	680	36 (91)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Excellent
Apron Taxiway 2	14 (36)	P.C.C.	820	36 (91)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Fair

* Jinglestone was quarried from interlayered deposits of sandstone, shale, sandy shale and slate.

Table 2. Summary of Physical Property Data (cont'd)

Facility No. and Identification	Pavement			Base			Subgrade	General Condition of Area
	Thickness in. (CM.)	Description	Flex. Str. psi	Thickness in. (CM.)	Description	K pci	Classification	
Apron Taxiway 3	14 (36)	P.C.C.	740	36 (91)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Excellent
Apron Taxiway 4	14 (36)	P.C.C.	710	36 (91)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Excellent
Apron Taxiway 5	16 (41)	P.C.C.	710	36 (91)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Excellent
Apron Taxiway 6	14 (36)	P.C.C.	710	36 (91)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Excellent
Parking Apron A	14 (36) 12 (30)	P.C.C.	820	36 (91)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Excellent
Parking Apron B	14 (36)	P.C.C.	710	36 (91)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Excellent
Parking Apron C	16 (41) 12 (30) 14 (36)	P.C.C.	710	36 (91)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Excellent
Parking Apron D	14 (36) 12 (30)	P.C.C.	710	36 (91)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Excellent
Royal Thai Navy Apron	14 (36) 12 (30)	P.C.C.	680	36 (91)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Excellent

* Jinglestone was quarried from interlayered deposits of sandstone, shale, sandy shale and slate.

Table 2. Summary of Physical Property Data (Cont'd)

Facility No. and Identification	Pavement			Base			Subgrade	General Condition of Area
	Thickness in. (CM.)	Description	Flex. Str. psi	Thickness in. (CM.)	Description	K pci	Classification	
Hanger Access Apron	12 (30)	P.C.C.	710	36 (91)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Excellent
North Warm-up Apron	16 (41)	P.C.C.	720	36 (91)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Excellent
South Warm-up Apron	12 (30)	P.C.C.	645	36 (91)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Very Good
Hardstands 1,2,3	18 (46) 16 (41)	P.C.C. (Center 25') P.C.C. (Outer Lanes)	725	72 (180)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Excellent
Hardstand 5	16 (41)	P.C.C.	625	36 (91)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Good
Hardstands 4-8	16 (41)	P.C.C.	625	36 (91)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Excellent
Hardstands 9-16	16 (41)	P.C.C.	720	36 (91)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Excellent
All Other Hardstands	18 (46) 16 (41)	P.C.C. (Center 25') P.C.C. (Outer Lanes)	725	72 (180)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Excellent
South and North Power Check	16 (41)	P.C.C.	645	36 (91)	Jinglestone* GW-GM	400	Brown Silty Sand (SM)	Excellent

*Jinglestone was quarried from interlayered deposits of sandstone, shale, sandy shale and slate.

Date of Evaluation
Month: July-August Year: 1969

Name of Airfield: Ban U-Tapao, Thailand

TABLE 3
SUMMARY OF ALLOWABLE GROSS AIRCRAFT LOADINGS

Main Landing Gear Types and Configurations

Facility No. and Identification	Pavement Operational Use	Single Wheel - Tricycle: 100 psi Tire Pressure (1)	Single Wheel - Tricycle: 100 Sq. In. Contact Area Each Tire (2)	Multiple Wheel - Tricycle Gear: TW 20" C-C 226 Sq. In. Contact Area Each Tire (3)	Multiple Wheel - Tricycle Gear: Single-Tandem Wheels 60" C-C, 400 Sq. In. Contact Area Each Tire (4)	Multiple Wheel - Tricycle Gear: TW 37" C-C 267 Sq. In. Contact Area Each Tire (5)	Multiple Wheel - Tricycle Gear: TW 44" C-C 630 Sq. In. Contact Area Each Tire (6)	Multiple Wheel - Tricycle Gear: Twin Tandem 31" - 63" 267 Sq. In. Contact Area Each Tire (7)	Multiple Wheel - Tricycle Gear: Dual TW Tandem 9-18-9-27-49 Sq. In. Contact Area Each Tire (8)	Bicycle Gear: Twin 37" C-C 267 Sq. In. Contact Area Each Tire (9)	Bicycle Gear: Twin Twin 37"-62"-37" 267 Sq. In. Contact Area Each Tire (10)	Traffic Area: Light A/C	Traffic Area: Heavy A/C
Rwy 18-36													
1000' Ends	Capacity	300,000	240,000	420,000	550,000	400,000	530,000	840,000	500,000	300,000	620,000	B	A
Interior	Capacity	195,000	155,000	285,000	380,000	275,000	370,000	600,000	350,000	200,000	430,000	B	A
Interior	Capacity	240,000	180,000	330,000	520,000	380,000	500,000	800,000	460,000	310,000	600,000	C	C
Primary Taxiway	Capacity	255,000	205,000	360,000	470,000	350,000	450,000	720,000	430,000	260,000	530,000	B	A
Access Taxiway 1	Capacity	190,000	150,000	275,000	360,000	260,000	350,000	560,000	330,000	195,000	410,000	B	A
Access Taxiway	Capacity	190,000	150,000	275,000	420,000	310,000	400,000	650,000	380,000	230,000	430,000	B	B
Access Taxiway 2	Capacity	235,000	189,000	330,000	430,000	320,000	410,000	650,000	390,000	235,000	480,000	A	B
Access Taxiway	Capacity	235,000	189,000	330,000	510,000	380,000	480,000	750,000	450,000	280,000	510,000	B	B
Hardstand Taxiway 1	Capacity	175,000	140,000	250,000	330,000	240,000	320,000	510,000	300,000	180,000	370,000	B	A
Hardstand Taxiway	Capacity	175,000	140,000	250,000	390,000	285,000	370,000	590,000	350,000	215,000	400,000	B	B
Hardstand Taxiway 2	Capacity	210,000	165,000	390,000	390,000	285,000	384,000	610,000	360,000	215,000	450,000	B	A
Hardstand Taxiway	Capacity	210,000	165,000	300,000	460,000	340,000	450,000	710,000	420,000	255,000	480,000	B	B
Hardstand Taxiway 3	Capacity	255,000	205,000	360,000	470,000	350,000	450,000	720,000	430,000	255,000	530,000	B	A
Hardstand Taxiway 4	Capacity	275,000	220,000	390,000	510,000	370,000	490,000	770,000	460,000	275,000	570,000	B	A
Cross Taxiway 1	Capacity	275,000	220,000	390,000	510,000	370,000	490,000	770,000	460,000	275,000	570,000	B	A
Cross Taxiways 2 and 3	Capacity	222,000	175,000	330,000	430,000	310,000	430,000	680,000	400,000	235,000	490,000	B	A
Cross Taxiway 4	Capacity	265,000	215,000	380,000	490,300	360,000	470,000	750,000	450,000	265,000	550,000	B	A
Apron Taxiway 1	Capacity	160,000	130,000	240,000	310,000	230,000	310,000	500,000	295,000	170,000	360,000	B	A
Apron Taxiway 2	Capacity	195,000	155,000	285,000	[illegible]	275,000	370,000	600,000	350,000	205,000	430,000	B	A
Apron Taxiways 3 and 4	Capacity	[illegible]	135,000	255,000	340,000	245,000	330,000	530,000	310,000	180,000	380,000	B	A
Apron Taxiway 5	Capacity	210,000	170,000	310,000	400,000	295,000	390,000	630,000	370,000	220,000	460,000	B	A
Apron Taxiway 6	Capacity	175,000	135,000	255,000	340,000	245,000	330,000	530,000	310,000	180,000	380,000	B	A
Parking Apron A	Capacity	150,000	120,000	225,000	360,000	260,000	360,000	570,000	330,000	195,000	370,000	B	B
Parking Apron B	Capacity	175,000	135,000	255,000	340,000	245,000	330,000	530,000	310,000	180,000	380,000	B	B
Parking Apron C 14"	Capacity	175,000	135,000	255,000	340,000	245,000	330,000	530,000	310,000	180,000	380,000	B	B
12"	Capacity	130,000	100,000	195,000	310,000	225,000	310,000	490,000	285,000	165,000	320,000	B	B
Parking Apron D	Capacity	130,000	100,000	195,000	310,000	225,000	310,000	490,000	285,000	165,000	320,000	B	B
Royal Thai Navy Apron	Capacity	125,000	95,000	185,000	295,000	215,000	295,000	470,000	276,000	160,000	310,000	B	B
Hangar Access Apron	Capacity	130,000	100,000	195,000	310,000	225,000	310,000	490,000	285,000	165,000	320,000	B	B
North Warmup Apron	Capacity	210,000	170,000	310,000	470,000	350,000	450,000	730,000	430,000	260,000	490,000	B	B
South Warmup Apron	Capacity	120,000	90,000	180,000	280,000	205,000	280,000	450,000	260,000	150,000	290,000	B	B
Hardstands 1-3, 17-23, 29-31	Capacity	260,000	210,000	370,000	570,000	420,000	540,000	860,000	510,000	310,000	580,000	B	B
Hardstands 4-8	Capacity	185,000	145,000	265,000	410,000	300,000	390,000	630,000	370,000	225,000	420,000	B	B
Hardstands 9-16	Capacity	210,000	170,000	310,000	470,000	350,000	450,000	730,000	430,000	260,000	490,000	B	B
North and South Power Check Pads	Capacity	190,000	150,000	275,000	420,000	310,000	400,000	650,000	380,000	230,000	430,000	B	B

Table 4

AIRCRAFT IDENTIFICATION INDEX								
Single Wheel		Multiple Wheel						
Tricycle		Tricycle						Bicycle
100 PSI TIRE PRESSURE	100 SQ. IN. CONTACT AREA EACH TIRE	TW 28" C-C 226 SQ. IN. CONTACT AREA EACH TIRE	SINGLE TANDEM 60" C-C 400 SQ. IN. CONTACT AREA EACH TIRE	TW 37" C-C 267 SQ. IN. CONTACT AREA EACH TIRE	TW 44" C-C 630 SQ. IN. CONTACT AREA EACH TIRE	TWIN TANDEM 33" x 48" 208 SQ. IN. CONTACT AREA EACH TIRE	C-5A GEAR CONFIGURATION	TWIN-TWIN 37" -62" -37" 267 SQ. IN. CONTACT AREA EACH TIRE
1	2	3	4	5	6	7	8	9
B-66	F-84	C-119	C-130	B-50	C-124	C-133	C-5A	B-52
C-45	F-86	C-54		KC-97		C-135		
C-47	F-89	C-118		C-97		KC-135		
C-46	F-94	C-131		C-121		C-141		
C-123	F-100	T-29				VC-137		
	F-101							
	B-57							
	F-102							
	F-104							
	F-105							
	F-106							
	F-111							
	F-4C							
	T-38							

Appendix A

CONDITION SURVEY NARRATIVE, PHOTOGRAPHS, AND DEFECT SUMMARIES

PAVEMENT CONDITION SURVEY

RUNWAY 18-36

General Condition - Very Good

One hundred sixty-five of 3680 total slabs (4.5 percent) were found to have major defects, mostly longitudinal or transverse cracks or corner breaks. About 50 percent of these cracks had been sealed. No evidence of settlement or differential movement of cracked slabs was noted by use of a 10-foot straight edge. However, visual observation of cracking patterns showed that two or three small areas of the runway may have settled slightly in areas comprised of roughly 6 to 12 slabs. Most defective slabs were cracked into two to four pieces, and most occurred in the lanes immediately to the left and right of the centerline (the travelled lanes) in which 15.2 percent of all slabs were cracked. This represents an increase of 7.7 percent over the 7.5 percent of these slabs found cracked in the 1968 evaluation.

The cracked slabs appeared to follow a reasonably random pattern along the length of the runway, although some groupings or concentrations of defective slabs were evident. One of these concentrated defective areas is located about 900 feet from the south end of the runway. Distress in a group of 12 slabs was noted in this area during the 1968 evaluation, with some cracked slabs occuring in lanes outside the center two. Now, this distressed area has increased in size, somewhat with 15 slabs cracked, 8 of which are in lanes outside the center two. No evidence of lower-strength concrete was found in this area. Contour maps, however, indicate that the site lies near the course of an old klong (stream) over which 3 to 4 meters of fill was necessary during construction. It is thus possible that the subgrade support in this area may be lower than average. Approximately 50 percent of all cracks in this area were unsealed and showed evidence of incipient spalling.

A second pavement area where localized distress has occurred is at the intersection of the runway with Access Taxiway 2 and Cross Taxiway 2. The 1968 evaluation found that in this spot, the three rows of runway slabs corresponding to the width of the taxiways on either side contained 11 cracked slabs out of a total of 24. Now, this area contains 12 cracked slabs, an increase of only one slab. It would thus appear that the criteria established by the Air Force in 1968 of restricting taxiing operations over this area to unloaded aircraft has succeeded in stabilizing the pavement condition. At this location, all but the newly-discovered cracked slab have been routed and sealed.

One other concentrated area of distressed slabs centered on an area approximately 2500 feet from the north end of the runway. Twenty-two out of 44 slabs in the center two lanes (50 percent) were cracked at this location, an increase of 12 cracked slabs over those found cracked during the 1968 evaluation.

RUNWAY 18-36 Cont'd

Of all cracked slabs noted during the runway condition survey, approximately 50 percent were unrepaired, unsealed, and showed evidence of incipient spalling.

Minor slab defects were of varying types, including small joint spalls, patches, popouts and embedded wood. Approximately 16 percent of all slabs contained one or more of these minor defects. Joint spalls were usually very small, but some showed evidence of loosened particles and approximately 5 percent of these could be rated as severe. Except for a live 50-caliber cartridge, no loose material was observed on the runway.

Patches were constructed of either asphaltic concrete (AC) or epoxy concrete and were generally in good condition. Popouts and embedded wood observed were small and of little significance.

Approximately 15 percent of all slabs were observed with hairline crazing or surface shrinkage cracks. In a few instances, the larger of these cracks had been sealed. These cracks are surficial only, and have not shown any tendency to deteriorate since their condition was observed during the 1968 evaluation. (For typical defect photos, see Figures A-1 and A-2)

PARALLEL TAXIWAY

General Condition - Excellent

One hundred thirty-seven of 1374 total slabs (9.5 percent of all slabs) contained major defects, according to the foregoing Corps of Engineers criteria. Of these, 110 slabs were found to have longitudinal cracks directly down the centerline of the center lane. This is an increase of only 12 longitudinally-cracked, center lane slabs (2.9 percent) over those found to be cracked in the 1968 evaluation, and an overall increase in total cracked slabs of 19 slabs. Thus, the percentage of cracked slabs in this taxiway has risen only 1.4 percent.

It was noted in the 1968 evaluation report that such longitudinal cracking of the center lane of taxiway slabs (which occurred at U-Tapao soon after initial traffic began) is a common occurrence on channelized primary taxiways at heavy load airfields. When the cracking became apparent, a centerline joint was sawed in all remaining uncracked slabs. It appears that this effort has essentially stabilized further occurrences of uncontrolled cracking. In assigning an excellent rating to this facility, it was assumed that these centerline longitudinal cracks act basically as joints where none were placed and, as such, present a minimum structural deficiency.

PARALLEL TAXIWAY Cont'd

One group of seven adjoining slabs in the center lane was found to have severe surface map cracking, but most cracks were found to be sealed and no deterioration in condition since the 1968 evaluation was noted.

Minor defects noted were small joint spalls, embedded wood, and pop-outs. These minor defects occurred in about 14 percent of all slabs and were generally insignificant, although an increase in overall number of transverse joint spalls was found. Patching of minor defects had been extensively performed in over 230 slabs (17 percent), an increase of 90 patched slabs over the 1968 survey. Patches were made of asphaltic concrete or epoxy concrete and, except for a few instances of minor cracking or spalling at the edge of a patch, had not deteriorated since the 1968 evaluation.

Joint seal and asphaltic concrete shoulders were in excellent condition. (For photo see Figure A-3)

ACCESS TAXIWAY 1

(West Half)

General Condition - Failed

Twenty-two of 99 total slabs (22 percent) between the edge of the runway and the North Power Check Pad were found to have major structural defects. Twenty-one of these slabs were found in the center lane (64 percent of all center lane slabs). Nine of these were found to be pumping at the cracks, joints, or both. The slabs were all transversely cracked in such a manner that overloading and/or weak subgrade support could be assumed as the causative factor. Although all cracks have been routed and sealed, some differential movement of cracked-off pieces seems probable, as several sealed cracks have reopened and are pumping. Several severe spalls have also appeared along repaired cracks.

Because only B-52 traffic makes use of this taxiway, the "failed" pavement rating given this area was based on the large percentage of defective center lane slabs and on the evidence of pumping and probable differential movement under load.

About 20 percent of all slabs contained minor defects, usually transverse joint spalls. Joint seals were generally in excellent condition. Asphalt shoulders were in excellent condition. (See Figures A-4 to A-7)

ACCESS TAXIWAY 1

(East Half)

General Condition - Excellent

Five of 327 total slabs (1.5 percent) in this portion of the taxiway were found to contain structural defects (transverse cracks). These

ACCESS TAXIWAY 1 Cont'd

slabs were all confined to the center (travelled) lane. Minor occurrences of joint spalls, embedded wood, and popouts were observed. Thirteen slabs contained patches of minor defects. Asphalt shoulders and joint seal were in excellent condition, with a few occurrences of small embedded aggregate in the joint seal.

ACCESS TAXIWAY 2

General Condition - Excellent

Only one slab of 378 total slabs contained a structural defect. About 4 percent of all slabs contained minor defects, mostly joint spalls. All these defects, major and minor, occurred in the eastern half of the taxiway. The western half was rebuilt in 1968 after several slab failures had occurred. This portion is, at present, entirely free of major or minor defects. Joint seals and asphalt shoulders were in excellent condition.

HARDSTAND TAXIWAY 1

General Condition - Very Good

Approximately 500 feet of the south end of this taxiway was rebuilt in 1967 after pavement distress (severe cracking) occurred shortly after the pavement was subjected to traffic. This area is in near perfect condition. In the remainder of the taxiway 25 slabs (5.6 percent) contained major defects (usually transverse cracks). Of these, 20 cracked slabs occurred in the center lane (13.5 percent of center lane). The 1968 evaluation showed a total of 19 cracked slabs in this area, with 12 cracked center lane slabs. It was noted that about 10 of the present cracks had not been sealed and showed evidence of incipient spalling. About 20 slabs contained small patches of minor defects. A total of 73 slabs contained minor defects, mostly small joint spalls. Joint seals were in excellent condition, with infrequent occurrences of bubbling joints. Asphalt and concrete shoulders were in excellent condition. (See Figure A-8)

HARDSTAND TAXIWAY 2

General Condition - Excellent

Five of 342 slabs (less than 2 percent) were found to have major defects, mostly transverse cracks (the 1968 evaluation noted a total of 3 cracked slabs in this taxiway). An additional 65 slabs (19 percent)

HARDSTAND TAXIWAY 2 Cont'd

were found to have minor defects, mostly minor joint spalls, popouts, and embedded wood. Three slabs contained small patched areas, in good condition. Joint seal contained numerous small aggregates, but was in excellent condition. Shoulders were in excellent condition.

HARDSTAND TAXIWAY 3

General Condition - Excellent

No major structural defects were found in this taxiway. About 10 percent of all slabs contained minor defects. Joint seals were excellent with random embedded aggregate, and asphalt shoulders were in excellent condition.

HARDSTAND TAXIWAY 4

General Condition - Excellent

This taxiway, under construction during the 1968 evaluation, is now complete. No major defects were noted and only 4 slabs with minor defects (small joint spalls) were found. Joint seals and shoulders were in excellent condition.

CROSS TAXIWAY 1

General Condition - Excellent

One slab of a total of 78 slabs (1.4 percent) contained a structural defect (a longitudinal crack). Ten other slabs contained minor defects such as embedded wood and small joint spalls. Eleven slabs had had minor patches (AC) applied as repairs to minor defects. Joint seals and AC shoulders were in excellent condition.

CROSS TAXIWAY 2

General Condition - Excellent

No major defects were found. Nine slabs (12 percent) exhibited patches (AC or epoxy concrete). Patches were in very good condition, indicating no deterioration since the 1968 evaluation. Eleven slabs were found to contain very minor defects. Joint seals and AC shoulders were in excellent condition.

PAVEMENT CONDITION SURVEY

CROSS TAXIWAY 3

General Condition - Excellent

Two center lane slabs (2.5 percent of all slabs) were found to contain longitudinal cracks. An insignificant number of minor defects were found. Joint seal and AC shoulders were in excellent condition.

CROSS TAXIWAY 4

General Condition - Good

Nine of 78 total slabs were found to be cracked. Eight of the 9 cracked slabs occurred in the center (travelled) lane (31 percent of center lane slabs). These figures represented an increase of 6 cracked slabs in this taxiway since the 1968 evaluation. The "good" pavement rating given this facility was thus based on (1) the high percentage of cracked center lane slabs, and (2) to the sharp increase in cracked slabs since the 1968 evaluation.

Seven slabs were found to have surface map cracking. This cracking had been repaired by sealing and represented no structural deficiency. Eleven slabs contained small AC patch repairs of minor defects. Very few unrepaired minor defects (embedded wood and small spalls) were found. Joint seals and shoulders were in excellent condition. (See Figure A-9)

APRON TAXIWAY 1

General Condition - Excellent

No major defects were found. Very small percent of slabs contained minor defects, mostly embedded wood, and small joint spalls. Joint seals and shoulders were in excellent condition.

APRON TAXIWAY 2

General Condition - Fair

Twenty-four (38 percent) of a total of 63 slabs were cracked (an overall increase of 6 cracked slabs over those found in the 1968 evaluation). Fifteen of the defective slabs were cracked longitudinally along the centerline of the center row of slabs, similar to most cracks found in the Parallel Taxiway. As on the Parallel Taxiway, a sawed joint placed in the center of the center lane slabs appears to have prevented much additional uncontrolled center line cracking in this taxiway. Only one new center lane crack was found. Only 4 newly-cracked slabs were found in the south outer lane. Most of the cracks in this facility had been routed and sealed. (See Figure A-10)

APRON TAXIWAY 2 Cont'd.

A relatively large number of minor slab defects were noted, particularly small, unrepaired spalls along longitudinal joint (34 slabs). A total of 49 slabs (78 percent) out of 63 total slabs had minor defects. Joint seals and AC shoulders were in excellent condition.

APRON TAXIWAY 3

General Condition - Excellent

Three (5 percent) of 57 total slabs contained structural defects (no change from 1968 evaluation). All three defective slabs were in the center lane and all failed in longitudinal cracking. About 20 to 25 percent of all slabs contained minor defects, all small joint spalls. Nine slabs showed evidence of patching of minor defects. Patches were in good condition. Joint seals and shoulders were in excellent condition.

APRON TAXIWAY 4

General Condition - Excellent

Only one slab (center lane) of a total of 54 was found to be cracked (no change from 1968 evaluation). About 12 slabs were noted to have minor defects (22 percent), mostly small joint spalls. Joint seals and shoulders were in excellent condition.

APRON TAXIWAY 5

General Condition - Excellent

No major and no minor defects were found, except for one AC patch of a minor defect. Joint seals and shoulders are in excellent condition.

APRON TAXIWAY 6

General Condition - Excellent

No major defects were found. Thirteen percent of all slabs showed minor defects such as small spalls, popouts and embedded wood. Joint seals and shoulders were in excellent condition.

PARKING APRON A

General Condition - Excellent

Only 53 (1.5 percent) of a total of over 3600 slabs contained major structural defects. Most of these defective slabs were concentrated in

PARKING APRON A Cont'd.

only three rows of slabs roughly in the center of the apron and probably used as taxiing lanes. It should be noted that these three lanes are constructed of 12-inch concrete, but are located immediately adjacent (to the east of) three lanes of 14-inch concrete which were designed for taxi lanes (See Detailed Plan View, Fig. 4). A second small concentration of cracked slabs was found at the apron entrance to Apron Taxiway 2. The remaining defective slabs were randomly distributed.

About 145 slabs (4 percent) contained minor defects including embedded wood, small joint spalls, and popouts. Joint seals were in excellent condition.

PARKING APRON B

General Condition - Excellent

Fifty-two (2 percent) of the 2690 total slabs in Apron B contained major structural defects, an increase of 17 cracked slabs over those found during the 1968 evaluation. Thirty-six of these cracked slabs occurred in an almost continuous row along one of the center taxiing lanes of the apron (28 in this row in 1968 evaluation). Several other cracked slabs were grouped near the apron entrance to Apron Taxiway 3, and the remaining few scattered throughout the apron. The 1968 evaluation noted that no indication of low concrete strength could be found in the severely cracked row of slabs. Only about 3 percent of the apron slabs contained minor defects such as embedded wood, popouts, and small joint spalls. Joint seals were found to be in excellent condition.

PARKING APRON C

General Condition - Excellent

Although no cracked slabs were found on this apron during the 1968 evaluation, the present survey found 49 cracked slabs (4 percent) in the entire apron. The relative severity of this increase in number of cracked slabs is reduced, however, by the fact that (1) 35 of the 49 cracked slabs were found to have occurred in 6-foot wide concrete patches placed over trenches containing utilities and do not extend beyond the patch to the remainder of the original slab, and that (2) most of these cracks in the trench patch have been sealed. The few cracked slabs encountered which did contain bonafide structural defects were somewhat randomly located.

About 100 slabs (8 percent) were found to have minor defects, mostly small joint spalls. Joint seals were in excellent condition. (See Figure A-11)

PARKING APRON D

General Condition - Excellent

No major defects were found. Less than 5 percent of all slabs contained minor defects, mostly small joint spalls. Joint seal and asphaltic concrete shoulders were in excellent condition.

RTN APRON

General Condition - Excellent

No major defects were found. Approximately 5 percent of all slabs contained very minor defects. Joint seals and shoulders were in excellent condition.

HANGAR ACCESS APRON

General Condition - Excellent

No major defects were found. Approximately 6 percent of all slabs contained small joint spalls. Joint seals were in excellent condition.

NORTH WARM-UP APRON

General Condition - Excellent

Only one slab (less than 1 percent) was found to have a structural defect. About 9 percent of all slabs contained minor defects, mostly embedded wood and small joint spalls. Ten slabs contained small patches, in good shape. Joint seals were in excellent condition. Both seals and pavement showed no jet damage.

SOUTH WARM-UP APRON

General Condition - Very Good

Twenty-seven (11 percent) of approximately 240 slabs showed major structural defects (cracking). This is more than double the number of cracked slabs (11) found during the 1968 evaluation. About 7 percent of all slabs contained minor defects. Six slabs were found to have small patches, in good condition. Joint seals were in excellent condition.

PAVEMENT CONDITION SURVEY

NORTH POWER CHECK PAD

General Condition - Excellent

Only 2 (less than 2 percent) of 147 total slabs contained structural defects (transverse cracks). Six slabs contained patches of joint defects. Several of these were large patches, but were in good condition. About 6 percent of all slabs contained minor defects. Joint seal was in excellent condition.

SOUTH POWER CHECK PAD

General Condition - Excellent

Eight (4 percent) of a total of 213 slabs contained major structural defects, mostly corner breaks. Four of these cracked slabs have appeared since the 1968 evaluation, three of them in slabs near the location of the aircraft gear when parked. About 13 percent of all slabs contained minor defects. Joint seal was in excellent condition with a few cases of blown joint seal due to jet blast.

HARDSTAND NO. 5.

General Condition - Good

This hardstand contains 6 cracked slabs (22 percent) out of a total of 27 slabs in the facility. (All these cracks have occurred since the 1968 evaluation.) These cracked slabs are all located in the two outer lanes of the hardstand. None of the cracks had been sealed. About 12 slabs in the hardstand (over 40 percent) also contained small joint spalls. Joint seal was in excellent condition and concrete shoulders were in excellent condition. (See Figure A-12)

ALL OTHER HARDSTANDS

General Condition - Excellent

Of the remaining hardstands, Hardstand 1 was found to contain two cracked slabs, and Hardstands 4, 6, 13, 14 and 16 were found to have one cracked slab each. Few of these cracks were considered serious; some were only a few feet long. None of the cracks had been sealed, however. Approximately 12 percent of all hardstand slabs contained minor defects, mostly small joint spalls. A higher number of these minor defects were noted in Hardstands 4, 6, 7 and 8, with a relatively lower percentage of minor defects in the newer hardstands. Concrete shoulders and joint seals were found to be in excellent condition.

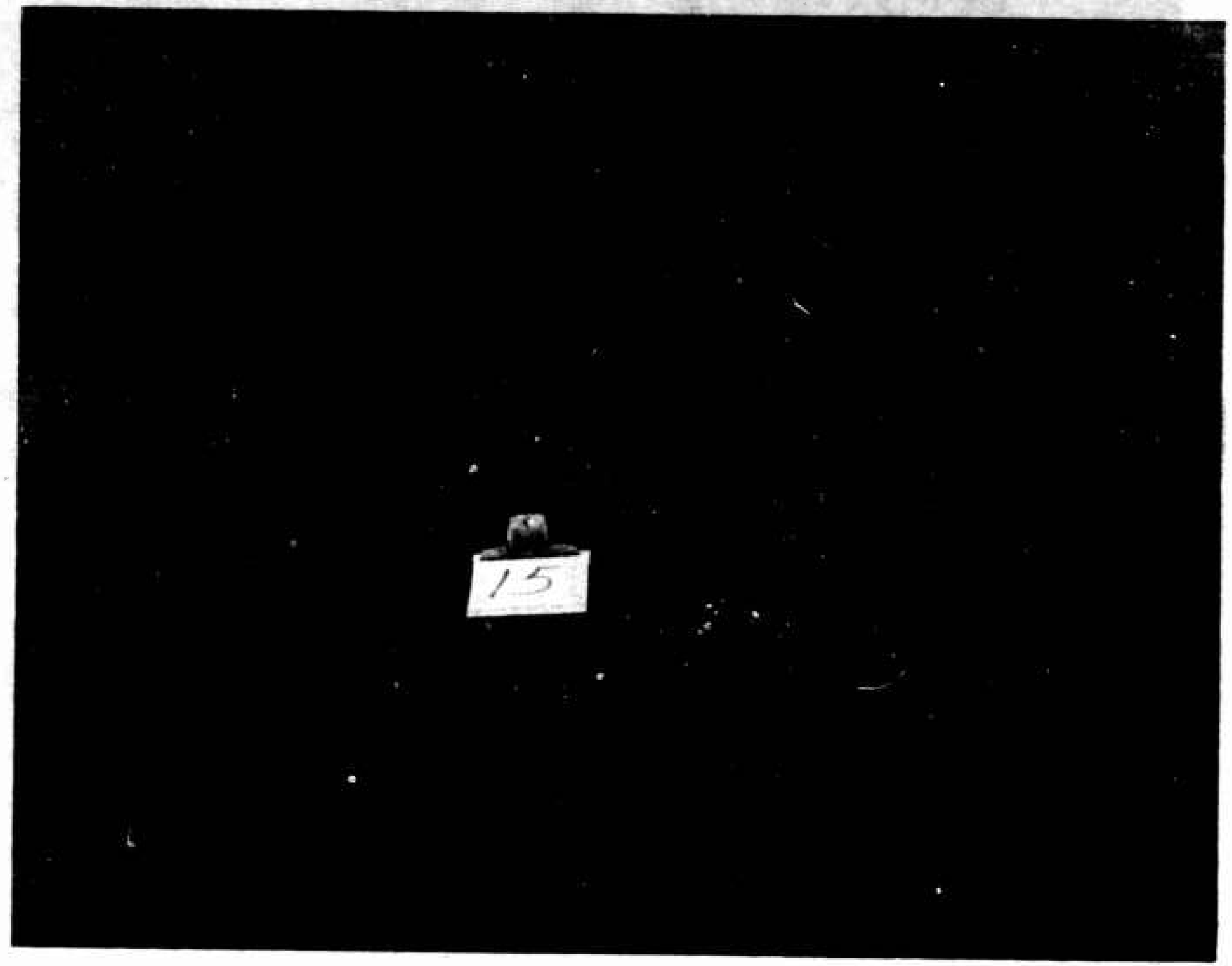


Figure A-1. Typical unsealed longitudinal crack in Runway 18-36, Ban U-Tapao Airfield.

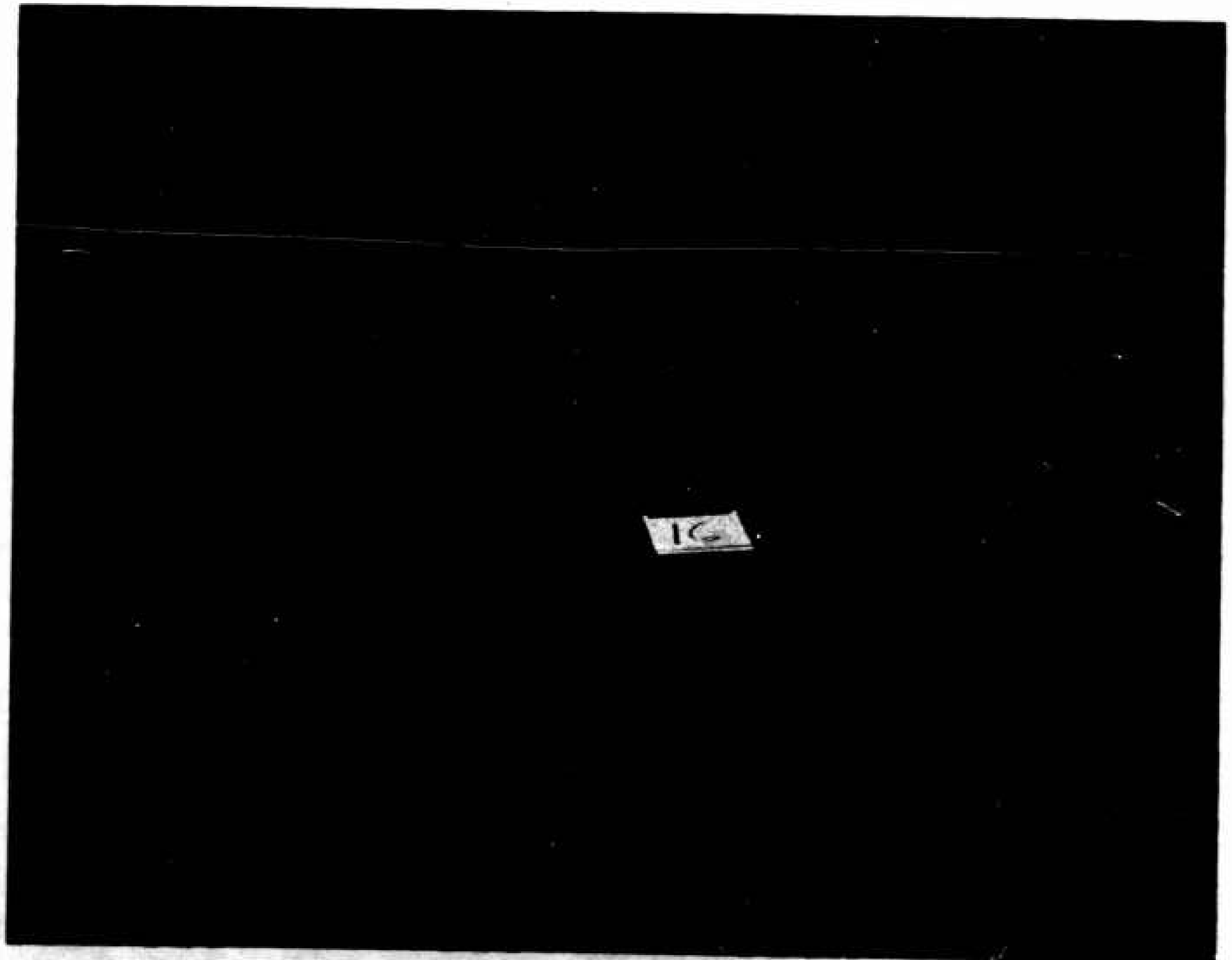


Figure A-2. Sealed, unsealed and patched cracks in Runway 18-36, Ban U-Tapao Airfield.

Figure A-3. Typical centerline and transverse cracking in Parallel Taxiway, Ban U-Tapao Airfield.

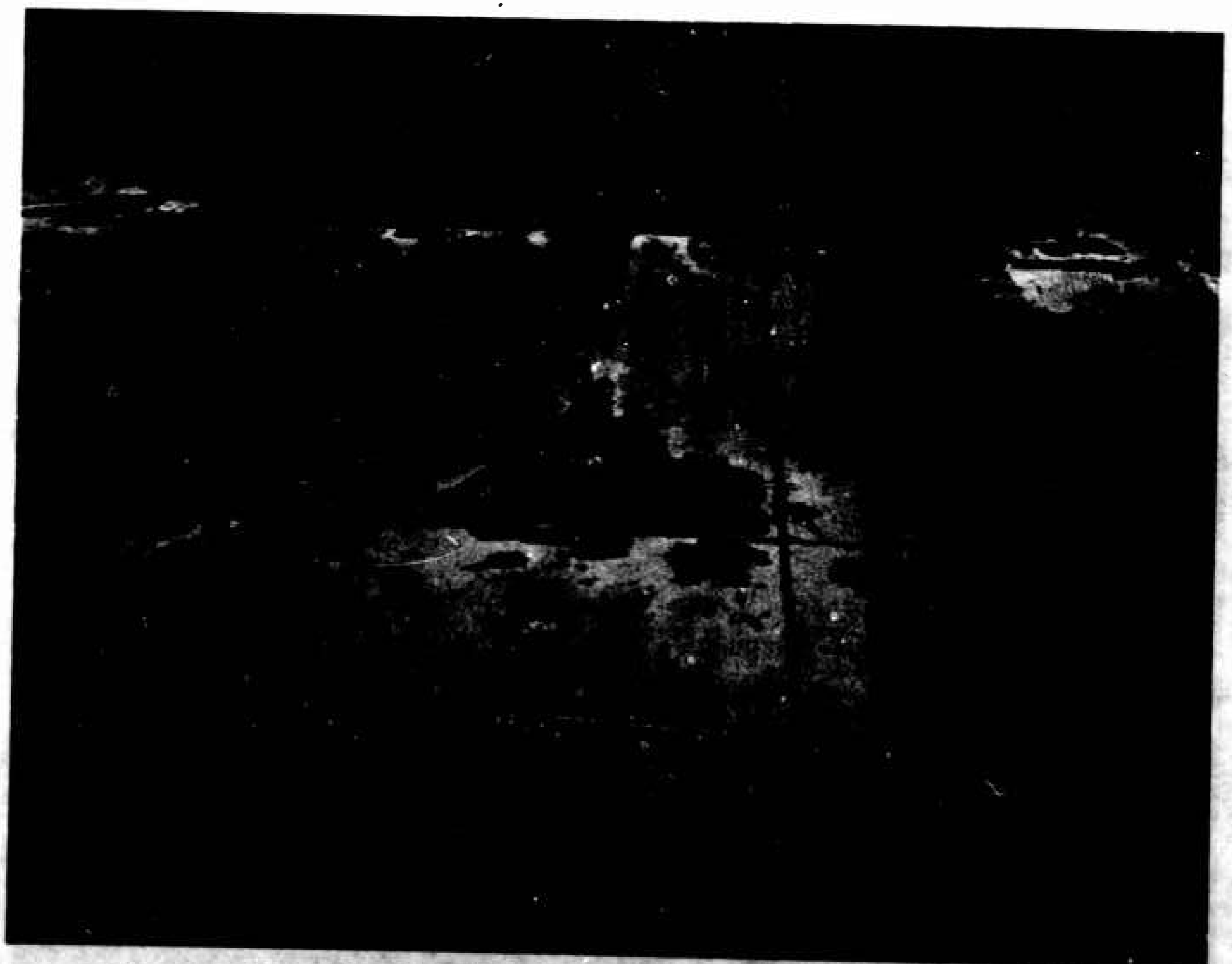


Figure A-4. Typical cracked and pumping area in Access Taxiway 1 (West), Ban U-Tapao Airfield.

Figure A-5. Close-up of pumping at crack, Access Taxiway 1 (West), Ban U-Tapao Airfield.

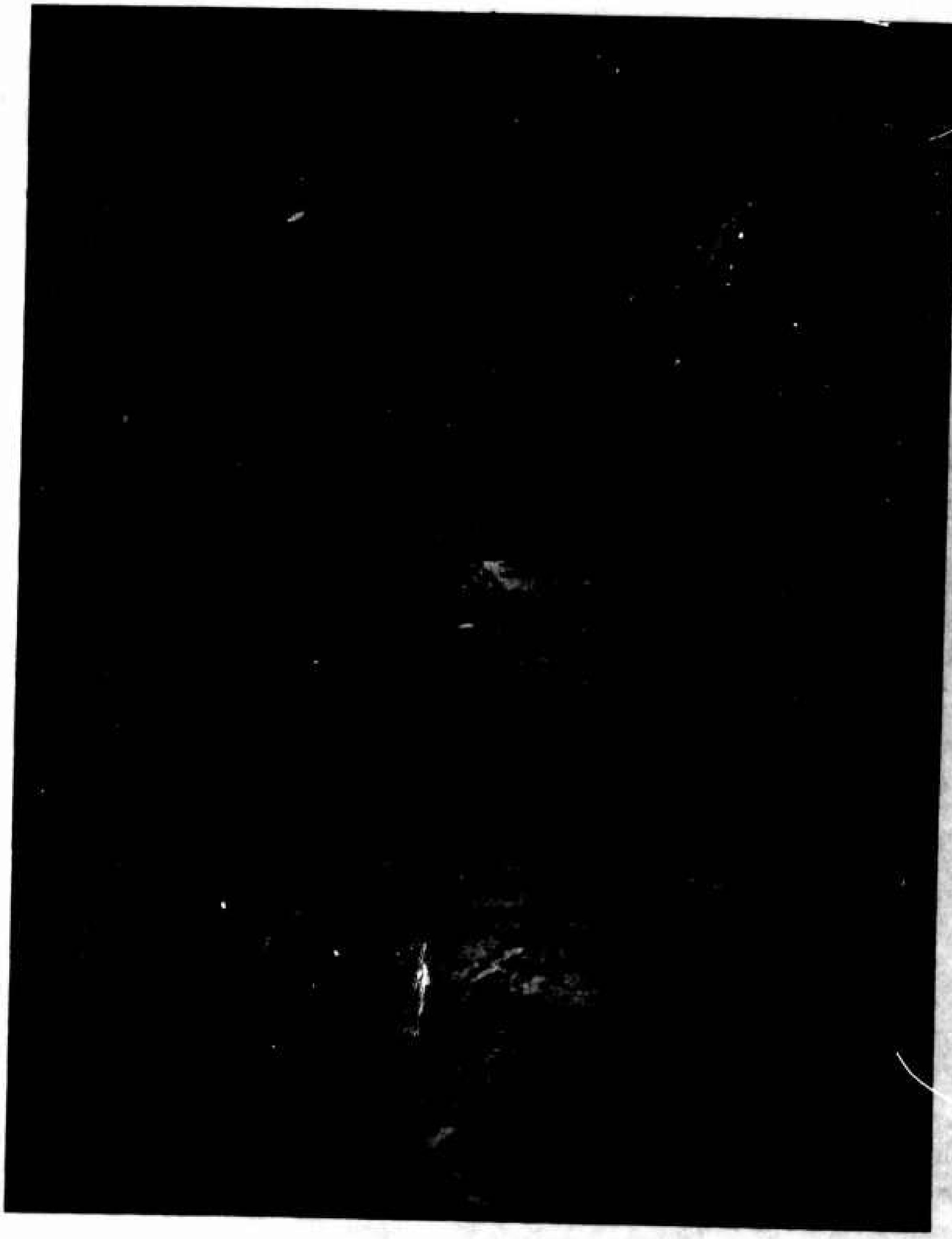


Figure A-6. Close-up of pumping at crack, Access Taxiway 1 (West), Ban U-Tapao Airfield.

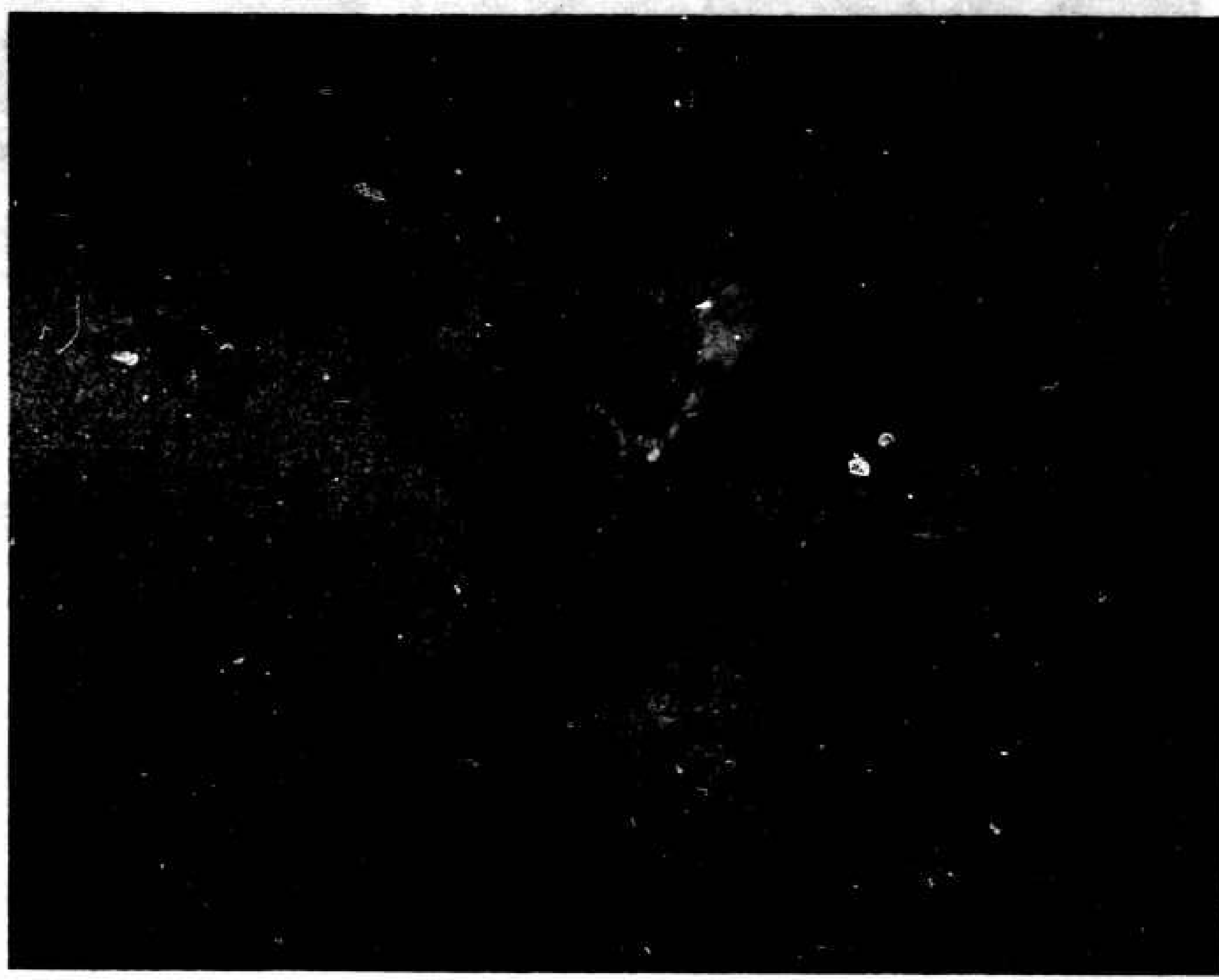


Figure A-7. Typical spalled joint on Access Taxiway 1 (West), Ban U-Tapao Airfield.

Figure A-8. Sealed and unsealed transverse cracks on Hardstand Taxiway 1, Ban U-Tapao Airfield.

Figure A-9. Close-up of spalling, unsealed crack in Cross Taxiway 4, Ban U-Tapao Airfield.

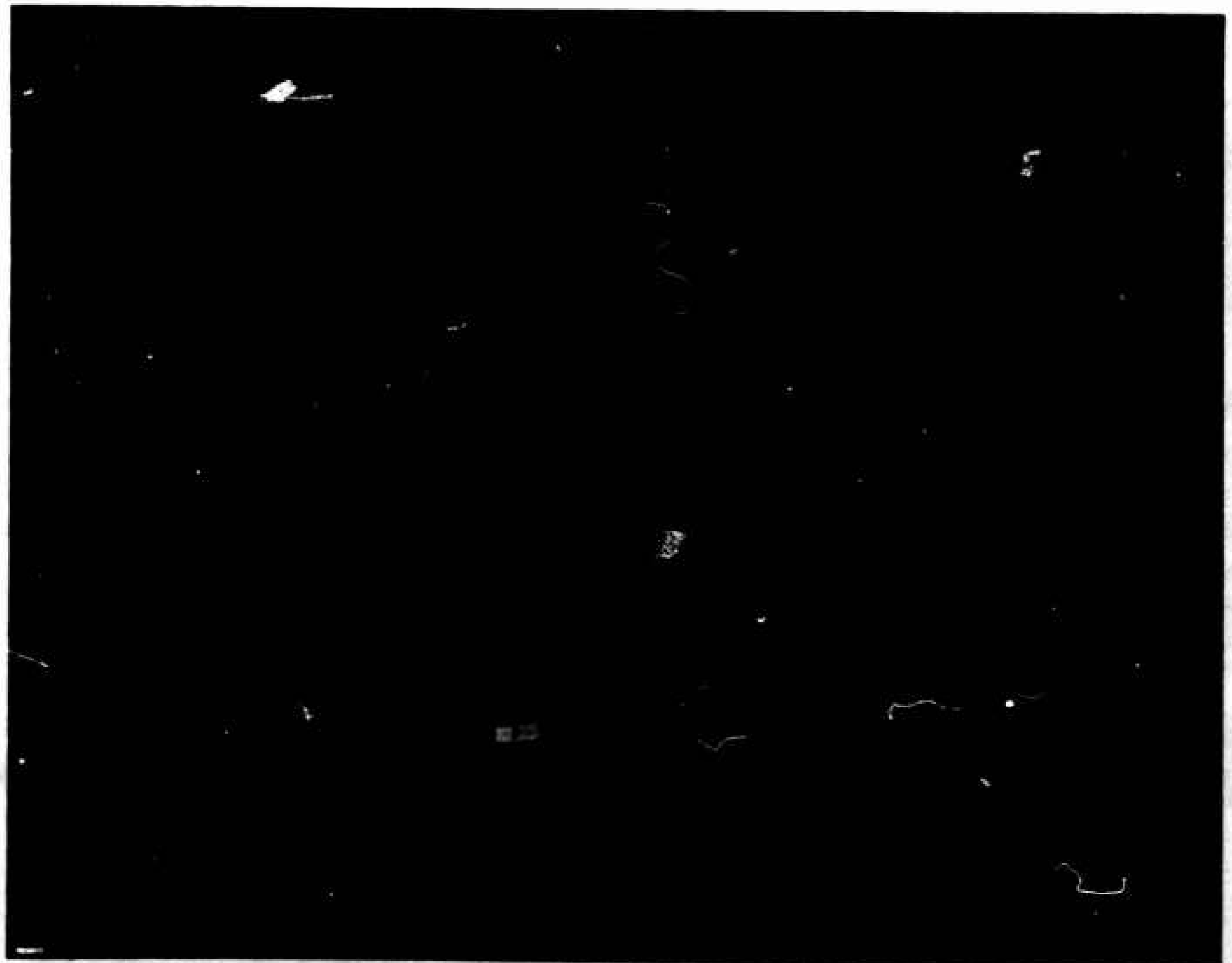


Figure A-10. General view showing cracking at intersection of Apron Taxiway 2 and Parking Apron A, Ban U-Tapao Airfield.

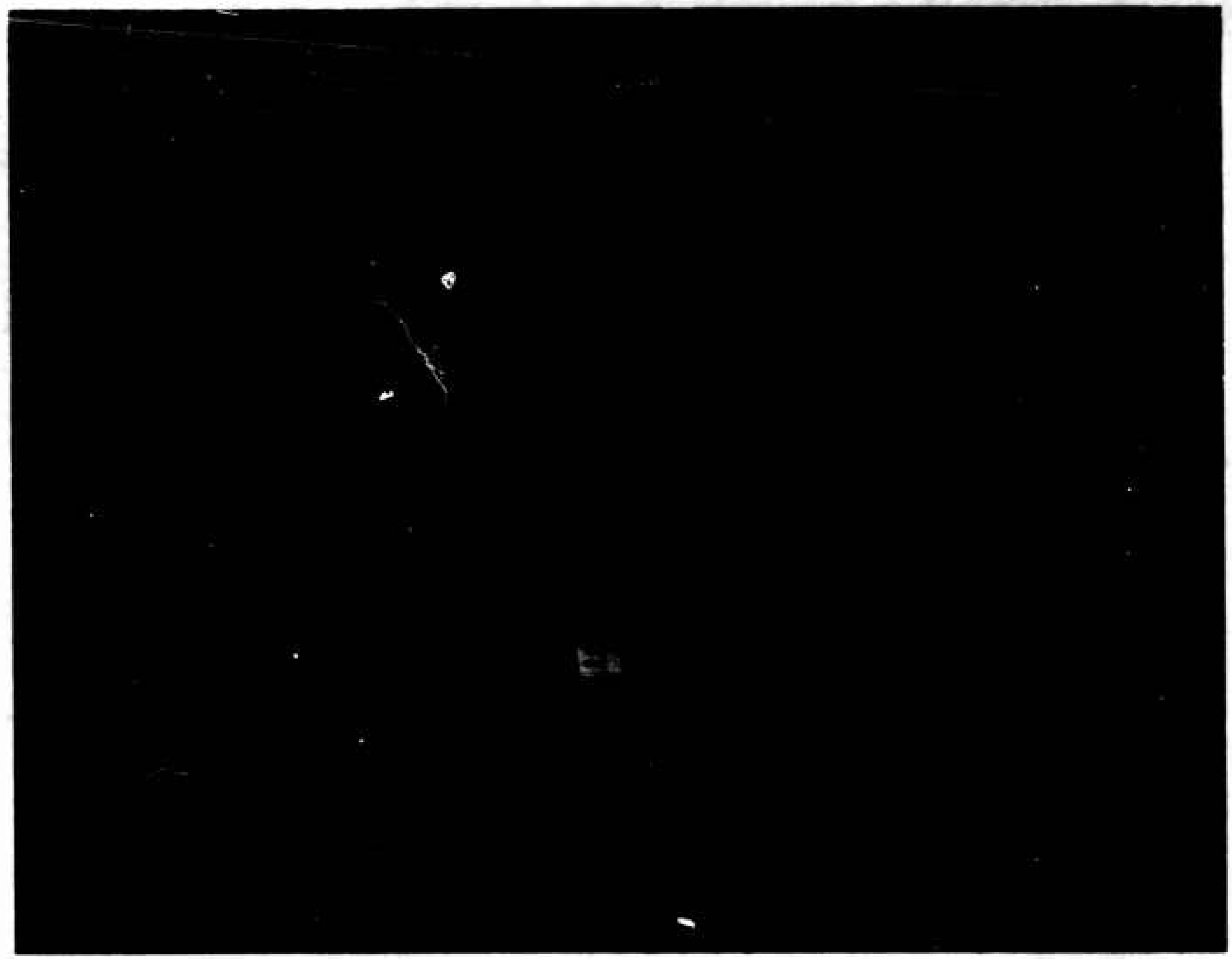


Figure A-11. General view of longitudinal cracking in trench patch in Parking Apron C, Ban U-Tapao Airfield.

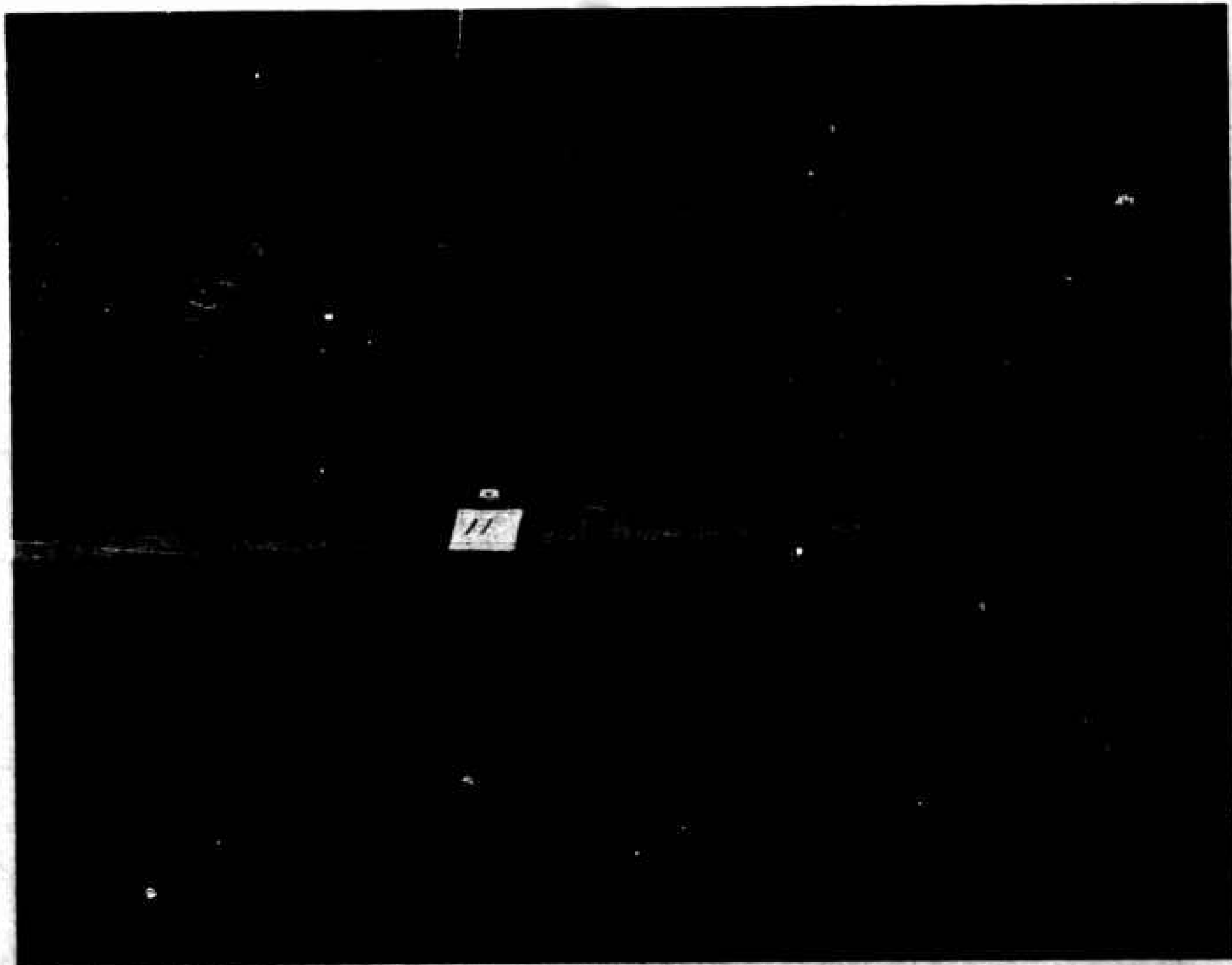


Figure A-12. Close-up of hairline longitudinal cracking in Hardstand 5, Ban U-Tapao Airfield.

DATE: July 1969	SUMMARY OF DATA – RIGID PAVEMENT CONDITION SURVEY																			AIRFIELD: U-Tapao, Thailand	
FEATURE	SLAB SIZE FT	APPROX NO. OF SLABS	PAVE. THICK. IN.	NO. OF SLABS CONTAINING INDICATED DEFECTS															% OF SLABS NO DEFECTS	% OF SLABS NO MAJOR DEFECTS	CONDITION
				│	—	╲	Δ	✱	∿	W	Spall on transverse joint	Spall on longitudinal joint	J	⯐	M	P	O	C			
Runway 18-36	25 x 25	3680	18& 14	71	39	---	72			278	190	20	10		---		70		80	95	Very Good*
Main Taxiway	25 x 25	1374	18& 16	117	36	---	5			31	89	27	23		7	9	10		78	91	Excellent**
Access Txy 1 (West)	25 x 25	99	16	---	21	---	1			3	14	2	1		---		1		60	78	Failed*
Access Txy 1 (East)	25 x 25	327	18& 16	---	5	---	---			3	18	2	---		---		1		92	98	Excellent
Access Taxiway 2	25 x 25	378	18& 16	1	1	---	---			5	8	---	1		---		1		96	99	Excellent
Hardstand Taxiway 1	25 x 25	444	18& 16	4	19	2	1			7	50	8	2		---		6		84	94	Very Good*
Hardstand Taxiway 2	25 x 25	342	16	---	4	1	---			9	40	10	---		---		6		80	99	Excellent
Hardstand Taxiway 3	25 x 25	315	18& 16	---	---	---	---			19	7	2	---		---		8		90	100	Excellent
Hardstand Taxiway 4	25 x 25	357	18& 16	---	---	---	---			---	4	---	---		---		---		99	100	Excellent
Cross Taxiway 1	25 x 25	78	18	1	---	---	---			3	5	---	2		---		---		86	99	Excellent

REMARKS:

* Most cracks occurred in center (travelled) lane or lanes (See Condition Survey Narrative)

** Uncontrolled longitudinal centerline cracking was not considered a full structural deficiency in rating this pavement facility (See Condition Survey Narrative)

LEGEND:

- │ LONGITUDINAL CRACK
- — TRANSVERSE CRACK
- ╲ DIAGONAL CRACK
- Δ CORNER BREAK
- ✱ SHATTERED SLAB
- ∿ SHRINKAGE CRACK
- W EMBEDDED WOOD
- SPALL ON TRANSVERSE JOINT
- SPALL ON LONGITUDINAL JOINT
- J CORNER SPALL
- ⯐ SETTLEMENT
- M MAP CRACKING
- P PUMPING JOINT
- O POP OUT
- C UNCONTROLLED CONTRACTION CRACK

Figure A-13. Summary of pavement defects.

DATE: July 1969 SUMMARY OF DATA – RIGID PAVEMENT CONDITION SURVEY AIRFIELD: U-Tapac, Thailand

FEATURE	SLAB SIZE FT	APPROX NO. OF SLABS	PAVE. THICK. IN.	NO. OF SLABS CONTAINING INDICATED DEFECTS															% OF SLABS NO DEFECTS	% OF SLABS NO MAJOR DEFECTS	CONDITION
				|	—	\	Δ	✱	〰	W	ɟ	ʄ	J	⌖	M	P	O	C			
Cross Taxiway 2	25 x 25	78	14	---	---	---	---			1	7	---	1		---		2		86	100	Excellent
Cross Taxiway 3	25 x 25	78	14	2	---	---	---			---	3	---	---		---		---		94	97	Excellent
Cross Taxiway 4	25 x 25	78	18	2	6	---	2			2	5	---	---		7		3		70	89	Good*
Apron Taxiway 1	25 x 25	378	14	---	---	---	---			6	5	6	1		---		2		95	100	Excellent
Apron Taxiway 2	25 x 25	63	14	23	1	---	1			2	9	34	4		---		---		< 10	62	Fair
Apron Taxiway 3	25 x 25	57	14	3	---	---	---			---	8	8	5		---		---		80	95	Excellent
Apron Taxiway 4	25 x 25	54	14	---	1	---	---			1	4	11	3		---		---		76	98	Excellent
Apron Taxiway 5	25 x 25	75	14	---	---	---	---			---	---	---	---		---		---		100	100	Excellent
Apron Taxiway 6	25 x 25	84	14	---	---	---	---			2	6	1	---		---		3		87	100	Excellent
Parking Apron A	25 x 25	3648	14& 12	41	7	5	3			16	80	25	12		---		16		94	98	Excellent

REMARKS:

* Most cracks occurred in center (travelled) lane or lanes (See Condition Survey Narrative)

LEGEND:

- | LONGITUDINAL CRACK
- — TRANSVERSE CRACK
- \ DIAGONAL CRACK
- Δ CORNER BREAK
- ✱ SHATTERED SLAB
- 〰 SHRINKAGE CRACK
- W EMBEDDED WOOD
- ɟ SPALL ON TRANSVERSE JOINT
- ʄ SPALL ON LONGITUDINAL JOINT
- J CORNER SPALL
- ⌖ SETTLEMENT
- M MAP CRACKING
- P PUMPING JOINT
- O POP OUT
- C UNCONTROLLED CONTRACTION CRACK

Figure A-14. Summary of pavement defects.

DATE: July 1969 **SUMMARY OF DATA — RIGID PAVEMENT CONDITION SURVEY** AIRFIELD: U-Tapao, Thailand

FEATURE	SLAB SIZE FT	APPROX NO. OF SLABS	PAVE. THICK. IN.	NO. OF SLABS CONTAINING INDICATED DEFECTS															% OF SLABS NO DEFECTS	% OF SLABS NO MAJOR DEFECTS	CONDITION
				|	—	\	Δ	*	~	W	Spall on transverse joint	Spall on longitudinal joint	J	⊕	M	P	O	C			
Parking Apron B	25 x 25	2690	14	41	4	---	8			7	50	7	13		---		16		95	98	Excellent
Parking Apron C	25 x 25	1176	16 14 12	29	17	---	13			5	65	12	35		---		2		88	96	Excellent
Parking Apron D	25 x 25	700	14& 12	---	---	---	---			---	4	25	2		---		2		96	100	Excellent
RTN Apron	25 x 25	168	14& 12	---	---	---	---			4	---	4	---		---		---		95	100	Excellent
Hangar Access Apron	25 x 25	234	12	---	---	---	---			---	14	---	---		---		---		94	100	Excellent
N. Warm-up Apron	25 x 25	220	16	1	---	---	---			7	10	4	---		---		2		91	99	Excellent
S. Warm-up Apron	25 x 25	240	12	21	3	---	7			1	10	2	1				4		83	89	Very Good
N. Power Check Pad	25 x 25	147	16	---	2	---	---			---	10	1	---				---		92	98	Excellent
S. Power Check Pad	25 x 25	213	16	1	1	---	7			---	24	6	2				---		83	96	Excellent
Hardstand No. 5	25 x 25	27	16	6	---	---	---			---	10	2	---				---		50	78	Good

REMARKS:

LEGEND:

|	LONGITUDINAL CRACK	~	SHRINKAGE CRACK	⊕	SETTLEMENT
—	TRANSVERSE CRACK	W	EMBEDDED WOOD	M	MAP CRACKING
\	DIAGONAL CRACK		SPALL ON TRANSVERSE JOINT	P	PUMPING JOINT
Δ	CORNER BREAK		SPALL ON LONGITUDINAL JOINT	O	POP OUT
*	SHATTERED SLAB	J	CORNER SPALL	C	UNCONTROLLED CONTRACTION CRACK

Figure A-15. Summary of pavement defects.

DATE: July 1969 **SUMMARY OF DATA – RIGID PAVEMENT CONDITION SURVEY** AIRFIELD: U-Tapao, Thailand

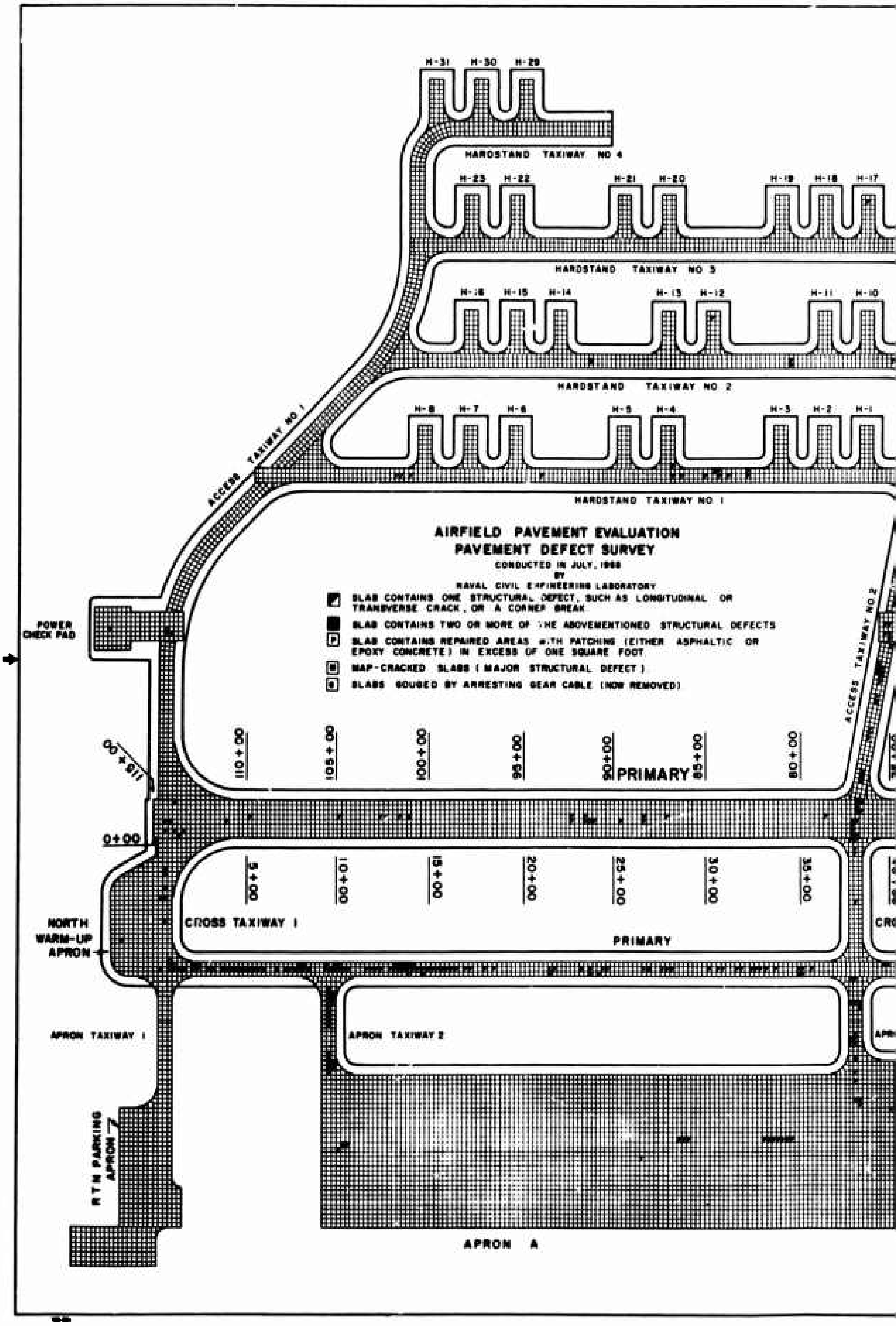
FEATURE	SLAB SIZE FT	APPROX NO. OF SLABS	PAVE. THICK. IN.	NO. OF SLABS CONTAINING INDICATED DEFECTS															% OF SLABS NO DEFECTS	% OF SLABS NO MAJOR DEFECTS	CONDITION
				I	—	\	Δ	✱	∿	W	ʆ	ɉ	J	⊕	M	P	O	C			
All other Hardstands	25 x 25	1000	18& 16	1	6	---	---			10	80	30	26		---		6		87	99	Excellent

REMARKS:

LEGEND:

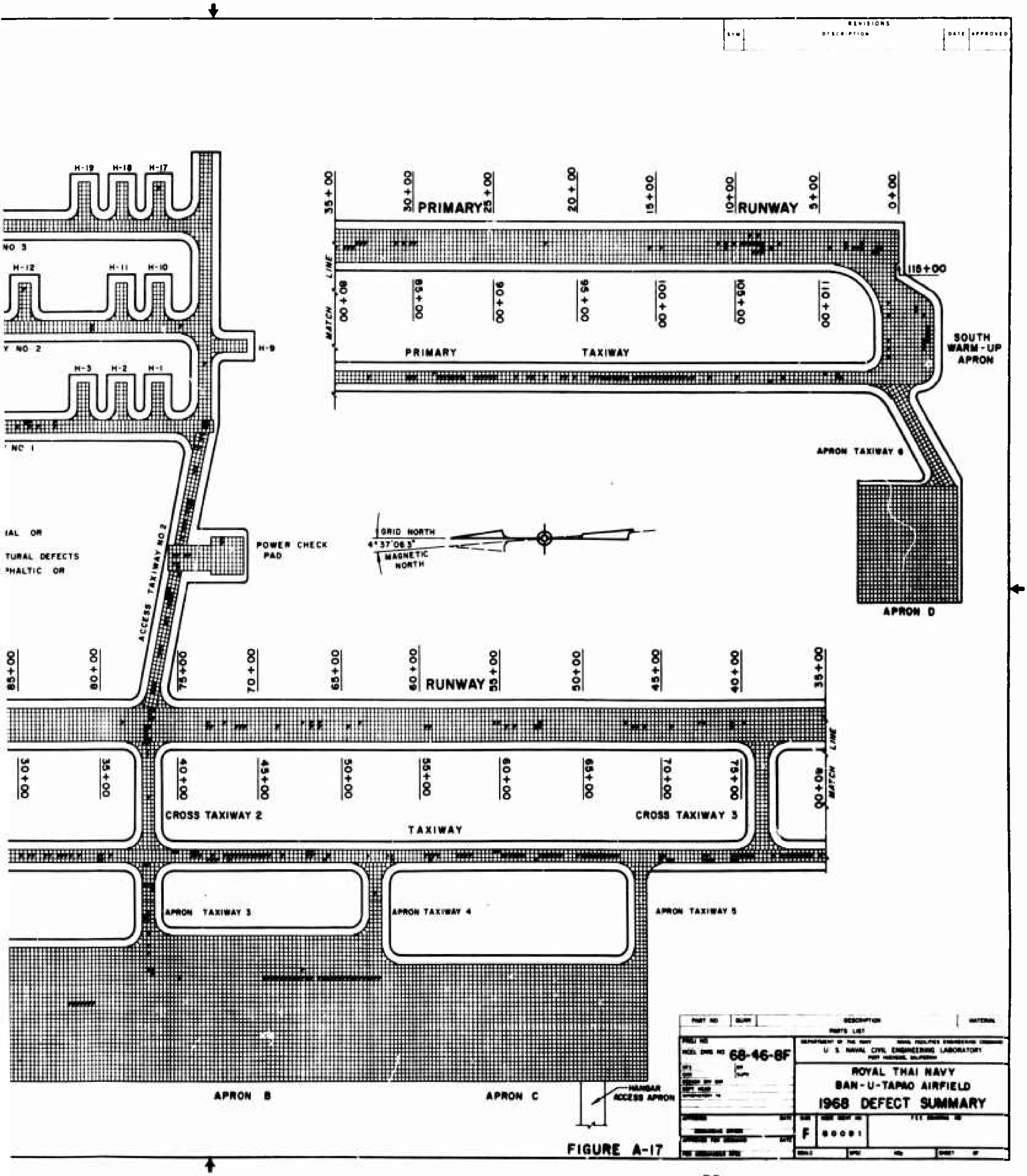
- I LONGITUDINAL CRACK
- — TRANSVERSE CRACK
- \ DIAGONAL CRACK
- Δ CORNER BREAK
- ✱ SHATTERED SLAB
- ∿ SHRINKAGE CRACK
- W EMBEDDED WOOD
- ʆ SPALL ON TRANSVERSE JOINT
- ɉ SPALL ON LONGITUDINAL JOINT
- J CORNER SPALL
- ⊕ SETTLEMENT
- M MAP CRACKING
- P PUMPING JOINT
- O POP OUT
- C UNCONTROLLED CONTRACTION CRACK

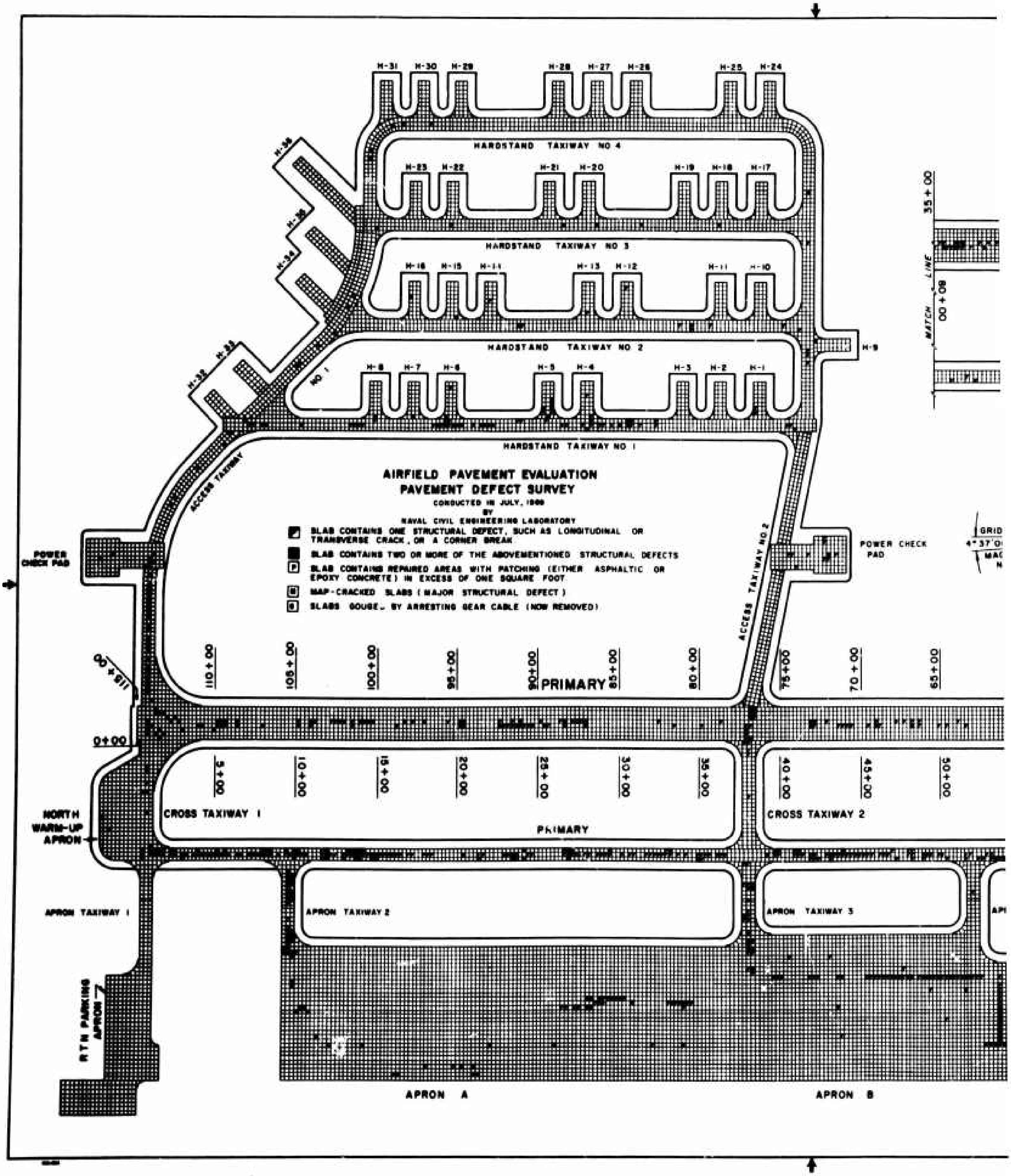
Figure A-16. Summary of pavement defects.



AIRFIELD PAVEMENT EVALUATION
PAVEMENT DEFECT SURVEY
CONDUCTED IN JULY, 1968
BY
NAVAL CIVIL ENGINEERING LABORATORY
SLAB CONTAINS ONE STRUCTURAL DEFECT, SUCH AS LONGITUDINAL OR TRANSVERSE CRACK, OR A CORNER BREAK
SLAB CONTAINS TWO OR MORE OF THE ABOVEMENTIONED STRUCTURAL DEFECTS
SLAB CONTAINS REPAIRED AREAS WITH PATCHING (EITHER ASPHALTIC OR EPOXY CONCRETE) IN EXCESS OF ONE SQUARE FOOT
MAP-CRACKED SLABS (MAJOR STRUCTURAL DEFECT)
SLABS GOUGED BY ARRESTING GEAR CABLE (NOW REMOVED)
H-31 H-30 H-29
HARDSTAND TAXIWAY NO 4
H-23 H-22 H-21 H-20 H-19 H-18 H-17
HARDSTAND TAXIWAY NO 3
H-16 H-15 H-14 H-13 H-12 H-11 H-10
HARDSTAND TAXIWAY NO 2
H-8 H-7 H-6 H-5 H-4 H-3 H-2 H-1
HARDSTAND TAXIWAY NO 1
ACCESS TAXIWAY NO 1
ACCESS TAXIWAY NO 2
POWER CHECK PAD
110+00
105+00
100+00
95+00
90+00
PRIMARY
85+00
80+00
115+00
0+00
5+00
10+00
15+00
20+00
25+00
30+00
35+00
CROSS TAXIWAY I
PRIMARY
NORTH WARM-UP APRON
APRON TAXIWAY I
APRON TAXIWAY 2
RTN PARKING APRON
APRON A

A


PRIMARY
RUNWAY
MATCH LINE
PRIMARY
TAXIWAY
116+00
SOUTH WARM-UP APRON
APRON TAXIWAY 6
APRON D
GRID NORTH
MAGNETIC NORTH
POWER CHECK PAD
ACCESS TAXIWAY NO 2
H-19
H-18
H-17
H-12
H-11
H-10
H-9
H-3
H-2
H-1
RUNWAY
CROSS TAXIWAY 2
TAXIWAY
CROSS TAXIWAY 3
APRON TAXIWAY 3
APRON TAXIWAY 4
APRON TAXIWAY 5
APRON B
APRON C
HANGAR ACCESS APRON
68-46-8F
U. S. NAVAL CIVIL ENGINEERING LABORATORY
ROYAL THAI NAVY
BAN-U-TAPAO AIRFIELD
1968 DEFECT SUMMARY
FIGURE A-17



H-31 H-30 H-29 H-28 H-27 H-26 H-25 H-24
HARDSTAND TAXIWAY NO 4
H-23 H-22 H-21 H-20 H-19 H-18 H-17
HARDSTAND TAXIWAY NO 3
H-16 H-15 H-14 H-13 H-12 H-11 H-10
HARDSTAND TAXIWAY NO 2
H-8 H-7 H-6 H-5 H-4 H-3 H-2 H-1
H-9
HARDSTAND TAXIWAY NO 1
AIRFIELD PAVEMENT EVALUATION
PAVEMENT DEFECT SURVEY
BY
NAVAL CIVIL ENGINEERING LABORATORY
SLAB CONTAINS ONE STRUCTURAL DEFECT, SUCH AS LONGITUDINAL OR TRANSVERSE CRACK, OR A CORNER BREAK
SLAB CONTAINS TWO OR MORE OF THE ABOVEMENTIONED STRUCTURAL DEFECTS
SLAB CONTAINS REPAIRED AREAS WITH PATCHING (EITHER ASPHALTIC OR EPOXY CONCRETE) IN EXCESS OF ONE SQUARE FOOT
MAP-CRACKED SLABS (MAJOR STRUCTURAL DEFECT)
SLABS GOUGED BY ARRESTING GEAR CABLE (NOW REMOVED)
ACCESS TAXIWAY
ACCESS TAXIWAY NO 2
POWER CHECK PAD
POWER CHECK PAD
MATCH LINE
35+00
80+00
110+00 105+00 100+00 95+00 90+00 85+00 80+00 75+00 70+00 65+00
PRIMARY
0+00
5+00 10+00 15+00 20+00 25+00 30+00 35+00 40+00 45+00 50+00
CROSS TAXIWAY 1
CROSS TAXIWAY 2
PRIMARY
NORTH WARM-UP APRON
APRON TAXIWAY 1
APRON TAXIWAY 2
APRON TAXIWAY 3
RTN PARKING APRON
APRON A
APRON B

A

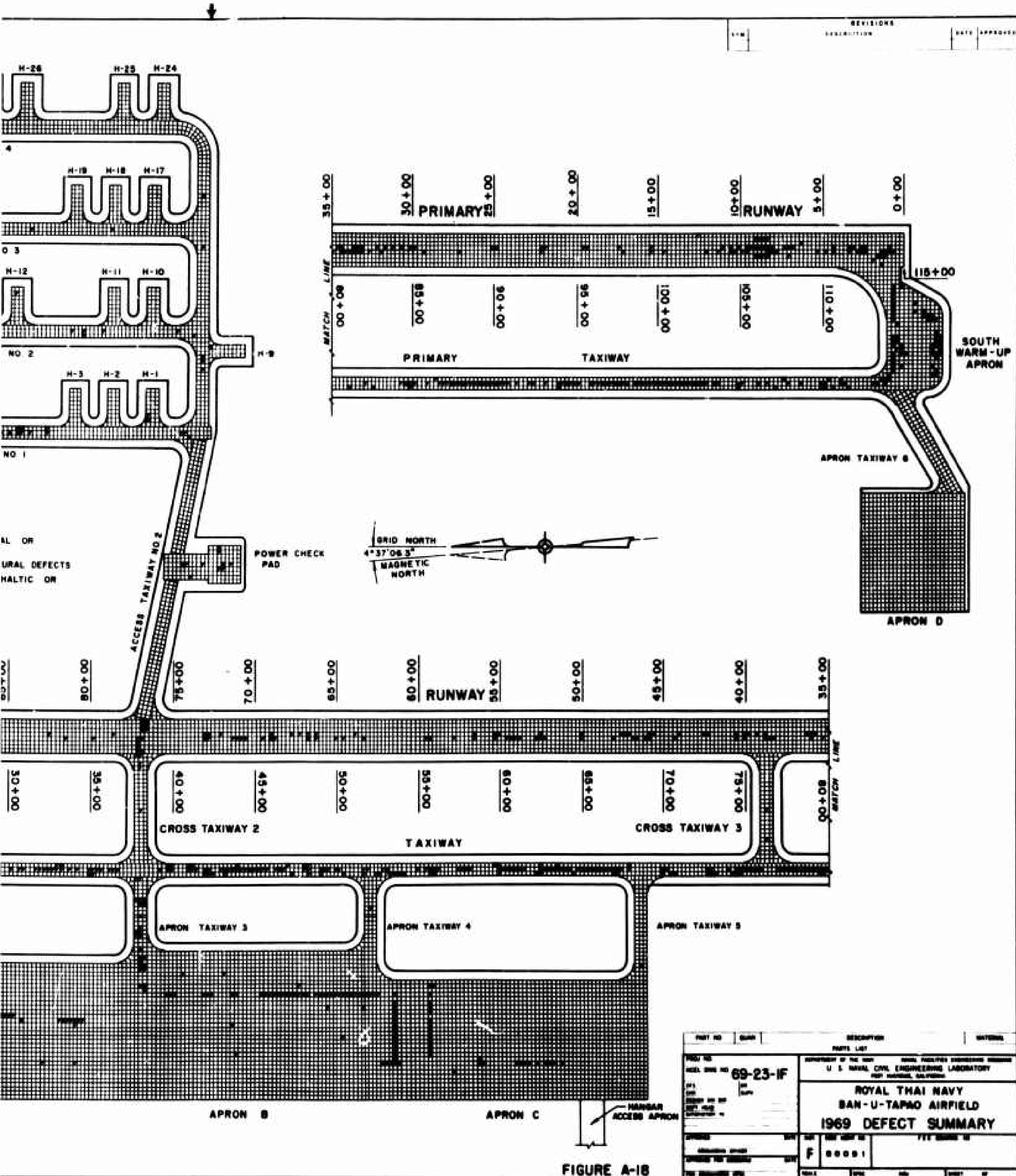

REVISIONS
H-26
H-25
H-24
H-19
H-18
H-17
H-12
H-11
H-10
H-3
H-2
H-1
H-9
35+00
30+00
PRIMARY
25+00
20+00
15+00
10+00
RUNWAY
5+00
0+00
115+00
MATCH LINE
80+00
85+00
90+00
95+00
100+00
105+00
110+00
PRIMARY
TAXIWAY
SOUTH WARM-UP APRON
APRON TAXIWAY 6
ACCESS TAXIWAY NO 2
POWER CHECK PAD
GRID NORTH
4°37'06.3"
MAGNETIC NORTH
APRON D
80+00
75+00
70+00
65+00
60+00
RUNWAY
55+00
50+00
45+00
40+00
35+00
30+00
35+00
40+00
45+00
50+00
55+00
60+00
65+00
70+00
75+00
80+00
MATCH LINE
CROSS TAXIWAY 2
TAXIWAY
CROSS TAXIWAY 3
APRON TAXIWAY 3
APRON TAXIWAY 4
APRON TAXIWAY 5
APRON B
APRON C
HANGAR ACCESS APRON
69-23-IF
U. S. NAVAL CIVIL ENGINEERING LABORATORY
ROYAL THAI NAVY
BAN-U-TAPAO AIRFIELD
1969 DEFECT SUMMARY
F

FIGURE A-18

B

Appendix B

PAVEMENT LIFE CALCULATIONS

Appendix B

PAVEMENT LIFE CALCULATIONS

BACKGROUND

During the 1969 evaluation, the NCEL evaluators were asked to prepare an estimate of remaining pavement life for Runway 18-36. The preparation of this prognostication is the subject of this appendix.

Predictions of airfield pavement life are possible because pavement design curves for selecting design thicknesses are based on the criterion of a known, finite pavement life in terms of "coverages" of the design aircraft. (Reference 4). Coverage is a term used to define the number of maximum stress repetitions that occur in the pavement due to the aircraft operations. By definition, a coverage occurs when each point of the pavement surface has been subjected to one maximum stress by the operating aircraft. (Reference 4). It should be noted that many operations are conducted with aircraft at less than maximum loads, thus these operations do not produce maximum stresses and present practice is to ignore them in the computation of coverages. At Ban U-Tapao specifically, B-52 aircraft operate at a maximum gross (loaded) weight of 420,000 lbs. Two passes of these loaded aircraft are required to equal one coverage on Type "A" traffic areas (runway ends), and five passes of the loaded aircraft equals one coverage on Type "C" traffic areas (runway interior).

Methods for estimating remaining pavement life were found in Reference 4, dated May 1966, and in Reference 5, dated March 1962. The pavement life approaches in both reports are based on the same fundamental research on concrete fatigue, but the methodology outlined in the more up-to-date report, Reference 4, is much less ponderous. Therefore, the pavement life estimates that follow are based on Reference 4.

ESTIMATES OF FUTURE RUNWAY PAVEMENT LIFE

Reference 4 (Figure 3) relates total design pavement life (in coverages) to the design safety factor used in the pavement design. This design safety factor is obtained by the formula:

$$\text{Design Safety Factor} = \frac{\text{Design concrete flexural strength}}{\text{Maximum stress in pavement by design aircraft}}$$

As in all construction, however, actual pavements do not always have the precise strengths specified, some sections being weaker and some stronger. Thus, it follows that if actual strength values and actual stress values could be substituted in the equation, an actual, rather than design, safety factor would result which would allow a more accurate estimate of pavement life. For Ban U-Tapao airfield pavements, actual strength and

stress data are available or can be calculated from data contained in the 1968 and present (1969) NCEL evaluations. Actual safety factors (ASF) can be calculated by the formula:

$$ASF = \frac{\text{Actual concrete flexural strength}}{\text{Actual pavement stress by loaded B-52}}$$

Table B-1 contains calculated safety factors and basic pavement and traffic data for several critical pavement facilities at Ban U-Tapao. Facilities listed include Hardstand No. 1, which failed only a few months after B-52 operations began; Access Taxiway 2 which failed in early 1968; Access Taxiway 1, which failed in early 1969; and Runway 18-36. It can be seen that safety factors for the runway have been calculated for two possible flexural strength levels: (1) for a flexural strength of 825 psi as determined during the 1968 evaluation and (2) for a hypothetical flexural strength of only 700 psi as required by the design specifications. In addition, past traffic (in terms of both loaded operations and coverages) is shown.

The dotted curve of Figure B-1, adapted from Figure 3 of Reference 4, shows the predicted relationship between pavement safety factor and the number of coverages that will produce "initial failure" of the pavement. Three pavement facilities already have failed at Ban U-Tapao. They are Hardstand No. 1, Access Taxiway No. 1, and Access Taxiway No. 2. The actual safety factor shown in Table B-1 for each of these three failed sections was plotted in Figure B-1 versus the respective number of coverages experienced up to the time of failure. The plotted failure points correlate very closely with the failure-prediction curve. This lends credence to the curve as a predictor of pavement life at Ban U-Tapao if used with the actual safety factors rather than the hypothetical "design" safety factors that were originally intended for use with the curve. It is a simple matter to enter the graph of Figure B-1 with an actual safety factor (from Table B-1) and learn the total number of coverages that will produce failure. The number of past coverages to date can be subtracted from the total allowable to determine the allowable number of coverages remaining. The quotient of remaining coverages and estimated rate of coverage is the estimated remaining life of the pavement. Such estimates are plotted in Figure B-1. The life estimates should be revised from time to time if the rates of coverage vary from the original estimates.

Basically, Figure B-1 shows that Runway 18-36 has a much higher total life expectancy than did the pavements which have already failed and has considerable life remaining before "initial failure" i.e. before 50 percent of the center lane slabs have been cracked into from 2 to 5 pieces. Calculations indicate that the runway interior may reach this condition in from 11 to 33 years. The runway ends have a slightly shorter life expectancy, ranging from a minimum of 6.5 to a maximum of 17 years. It should be noted, however, that even though "initial failure" may occur within the above time frames, this does not automatically mean that the pavement must be replaced or strengthened. It is possible that, after reaching "initial failure", the runway will require only an accelerated

maintenance effort during many additional years of life, particularly if the cracked slabs maintain their present integrity and do not evidence such severe complications as slab displacement, faulting, or pumping at cracks or joints. Should these defects appear, immediate maintenance and/or repair is recommended.

All predictions of possible future pavement performance presented in this report are not firm predictions, but are based on the best available evidence in combination with current procedures for predicting pavement life (which are, at best, only approximations). Other factors which tend to reduce pavement life, such as weathering, ageing, neglected maintenance, obstructed drainage, etc., were not considered in this procedure.

Table B-1. Pavement Facility Safety Factors and Related Pavement and Traffic Data.

Note: Critical aircraft in operation at Ban U-Tapao with respect to pavement life calc 420[K] lbs actual gross weight, twin-twin bicycle gear, wheel spacing 37x62x37 incl 267 sq. in.

Facility	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	(
	Pavement Thickness (in.)	Subgrade "k" (psi/in.)	Actual Concrete Flexural Strength (psi)	Flexural Strength Required by B-52[1] (psi)	Design Safety Factor[2]	Actual Safety Factor[3]	Past Loaded Aircraft Passes[4]	((
Original Hardstand No. 1 (Now replaced)	16	300	580[5]	770	1.59	1.20	120	
Access Txy 2 (West)(Now replaced)	16	350	615[5]	720	1.59	1.36	2,000	
Access Txy 1 (West) (Failed 1969)	16	400	645[5]	670	1.59	1.53	16,000	
Runway Ends (Type "A" Traffic)	18	400	825[5]	580	1.59	2.26	18,000	
Runway Ends (Type "A" Traffic)	18	400	700[6]	580	1.59	1.92	18,000	
Runway Interior (Type "C" Traffic)	14	400	825[5]	580	1.50	2.14	18,000	
Runway Interior (Type "C" Traffic)	14	400	700[6]	580	1.50	1.81	18,000	

[1]Equals B-52 flexural stress x design safety factor (for loaded B-52, 420[K] gross wt.) fr Engineers Manual EM 1110-45-303 of Feb. 1958.

[2]From Reference 4.

[3] $\text{ASF} = \frac{\text{Col. 3}}{\text{Col. 4}} \times \text{Col. 5}$

[4]Provided by Ban U-Tapao operations personnel.

[5]Flexural strength determined from beam and core tests during 1968 NCEL evaluation (Refe

[6]Flexural strength required by construction specifications.

[7]One coverage equals two passes of loaded aircraft.

[8]One coverage equals five passes of loaded aircraft.

A

Table B-1. Pavement Facility Safety Factors and Related Pavement and Traffic Data.

aircraft in operation at Ban U-Tapao with respect to pavement life calculations is the B-52, actual gross weight, twin-twin bicycle gear, wheel spacing 37x62x37 inches, wheel contact area :n.

	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
	Pavement Thickness (in.)	Subgrade "k" (psi/in.)	Actual Concrete Flexural Strength (psi)	Flexural Strength Required by B-52[1] (psi)	Design Safety Factor[2]	Actual Safety Factor[3]	Past Loaded Aircraft Passes[4]	Past Traffic (Coverages)	Estimated Future Traffic (Cov./month)[4]
	16	300	580[5]	770	1.59	1.20	120	60[7]	450[7]
ced)	16	350	615[5]	720	1.59	1.36	2,000	1,000[7]	450[7]
969)	16	400	645[5]	670	1.59	1.53	16,000	8,000[7]	450[7]
:)	18	400	825[5]	580	1.59	2.26	18,000	9,000[7]	450[7]
:)	18	400	700[6]	580	1.59	1.92	18,000	9,000[7]	450[7]
:)	14	400	825[5]	580	1.50	2.14	18,000	3,600[8]	180[8]
:)	14	400	700[6]	580	1.50	1.81	18,000	3,600[8]	180[8]

:ural stress x design safety factor (for loaded B-52, 420^K gross wt.) from Fig. 6, Corps of . EM 1110-45-303 of Feb. 1958.

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Col. 5

U-Tapao operations personnel.

h determined from beam and core tests during 1968 NCEL evaluation (Reference 1).

h required by construction specifications.

als two passes of loaded aircraft.

als five passes of loaded aircraft.

B

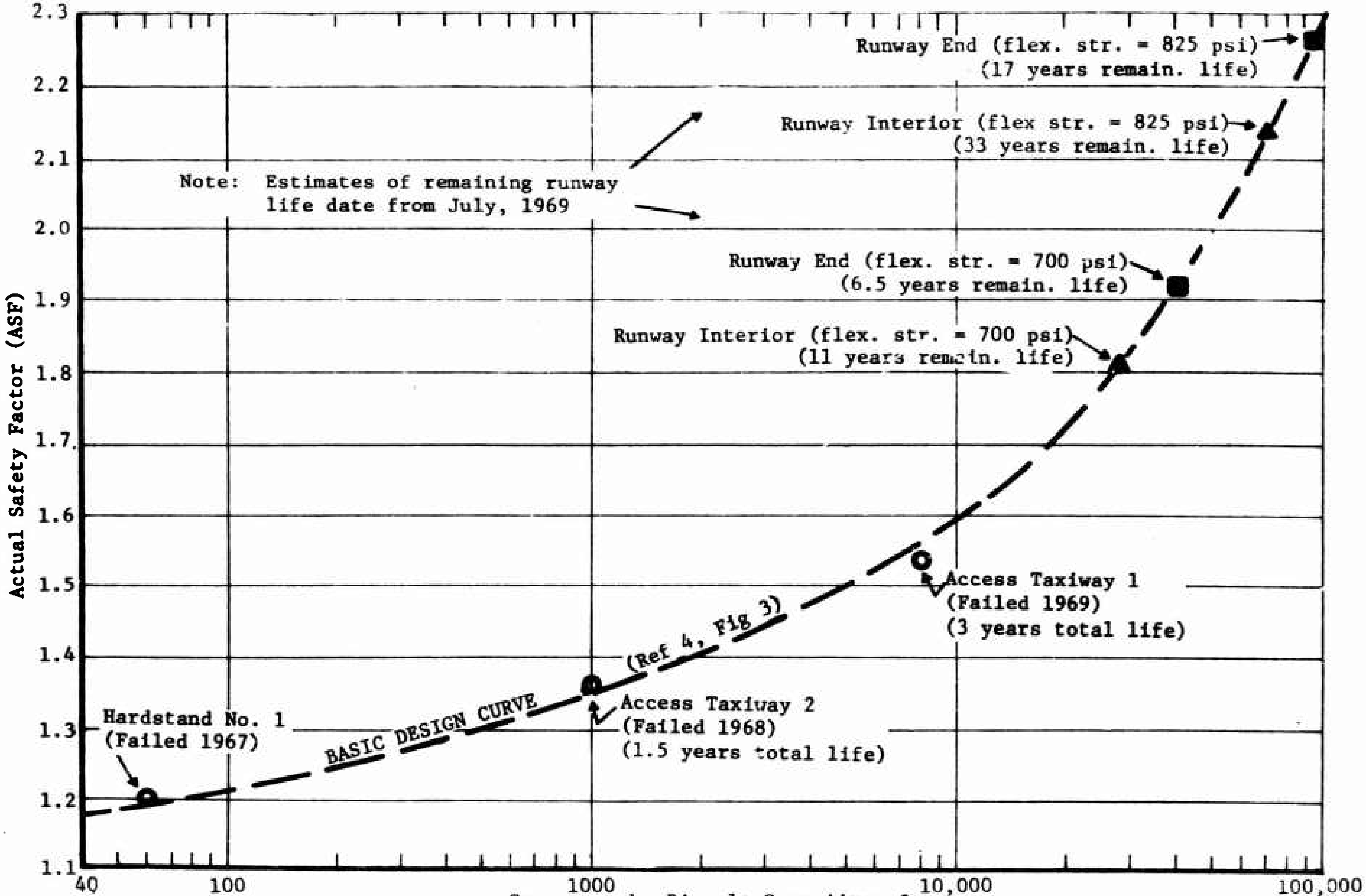

Figure B-1. Pavement safety factor versus aircraft coverages (i.e. "life") of pavement.

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13. ABSTRACT

The reevaluation of the pavement at the Royal Thai Navy Station, Ban U-Tapao Airfield, Thailand is presented with the allowable gross load capacities of all airfield pavements for various aircraft gear configurations. Included are a narrative-type pavement condition survey with a defect summary, supplementary photographs, and estimates of remaining runway pavement life.

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